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ABSTRACT

This document is the final report of a project on performance-based materials for use in an elementary science education teacher training program developed by personnel at Southwest Missouri State University, Springfield, Missouri. The materials developed in this project were designed to provide instruction and practice relative to certain cognitive understandings in science education. Attempts were made to identify alternative approaches from which teachers might choose in developing their own philosophy of science education and teaching style. Contents of this report are divided into twelve exercises or modules: Ends and Means and Pacing Learning Activities; Alternative Approaches in Elementary Science Education; Individualizing Instruction; Sources of Objectives and Emphases in Science; Differentiating Between Product and Process-Centered Instructional Objectives; Developing a Philosophy of Science Education; Identifying Guides to be Used in Planning, Directing and Evaluating Instructional Activities; Curricular Components of the Instructional Approaches; Developing Children's Potential Using the Experiential Approaches; Types of Science Activities; Developing a Proper Support System; and Improved Science Programs. Each of these modules consists of relevant information, a pretest and a post-test. Correct responses to the post-test are provided. The report concludes with pretest and post-test scores of students who used the materials during the tryout stages of the project. (PEB)

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Final Report

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Project No. 2G043
Grant No. OEG-7-72-0025 (509)

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PERFORMANCE-BASED MATERIALS FOR USE IN AN ELEMENTARY SCIENCE EDUCATION TEACHER TRAINING PROGRAM (Some Major Alternatives in Elementary School Science Education)

November, 1973

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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National Center for Educational Research and Development
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Abstract

The purpose of the project reported herein was to develop a set of performance-based curriculum materials for use in the training of elementary teachers in the area of science education.

The content of the materials is related to some of the major alternatives from which teachers may choose in developing or selecting and implementing elementary school science programs.

The materials developed include a statement of objectives for each unit or exercise, a pretest for each objective, an instructional module for each set of objectives, and a post-test for each objective.

The pretests, instructional modules, and post-tests were tried out with two small groups of students and were revised after each tryout. Pretest and post-test scores of both groups of students are included in the report.

Final Report

Project No. 2G043
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PERFORMANCE-BASED MATERIALS FOR USE IN AN ELEMENTARY SCIENCE EDUCATION TEACHER TRAINING PROGRAM

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November, 1973

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
National Center for Educational Research and Development
(Regional Research Program)

Preface

Teacher education personnel today are considering a number of components related to the training of teachers. Among the components are:

1. The knowledge component - the cognitive understandings or things the teacher should know about education, teaching, children, etc.

2. The teaching skills component - the actual competencies or skills which the teacher should possess, or desired teaching behaviors.

3. The product component - the combining of the knowledge and skills components into a program which results in measurable learner achievement.

Traditionally, teacher education has been mainly concerned with the knowledge component. Today, there is much interest in the teaching skills and product components. Obviously, each teacher educator must determine the components that comprise his program, and he must determine the proportion of his program to be devoted to each component.

These materials were developed to provide instruction and practice relative to certain cognitive understandings in science education. It is not intended, or suggested, that these materials comprise a total science education program or course.

Because we lack evidence that indicates one approach to science education in the elementary school is superior to another approach, these materials are not oriented toward the training of teachers in the use of a particular approach. Instead, an attempt was made to identify some alternatives from which teachers may choose in developing their own philosophy of science education and teaching style.

Many references were used in the development of the materials reported herein. Where feasible, credit was given in the report in the exercise or unit in which a reference was used. However, in some instances, it was not feasible to footnote, such as in pretests and post-tests and practice exercises. In addition to the references cited, the following references were consulted and ideas from them were incorporated into the project materials.

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Introduction

The materials which you select or develop when planning for science, and the manner in which you use materials in implementing your plans, depend greatly upon your knowledge of various approaches to science education, and upon how you view science for children in the elementary school.

How many different approaches are you able to use? How do you view science for elementary pupils? How *should* you view science for children? Do "authorities" agree as to which type of experience is best for children and as to the role the teacher and pupils should play during science activities?

It may take many years of reading and studying science education for the elementary school before you can give satisfying answers to questions such as those above. Also, it will take many science activities in which you play various roles as a teacher. Therefore, you should consider these exercises a first tiny step toward being able to teach science as you will someday think it should be taught.

Teaching is Decision Making

Let's assume you are a teacher (or soon will be), and you are about to assume responsibility for a group of children. You will have many decisions to make regarding the experiences you will provide your pupils throughout the year. Within a short time you will be making decisions such as these:

a. Should I be very strict the first few days?

or

Should I be "myself"?

Should I adhere to a rigid time schedule?

or

Should I have a flexible time schedule?

Should I plan in detail?

or

Should I make very brief plans and hope for the best?

Should I expect all children to complete the same tasks at the same time?

or

Should I allow students to work on a variety of tasks?

Most decisions have more than two alternatives and, therefore, are not either/or propositions. The successful teacher is the one who identifies the greatest number of alternatives and who chooses the best alternative from the many that may be available.

These materials are for the purpose of helping you to be a better decision-maker in teaching science. Some decisions regarding science which you and others in your school will likely have to make at one time or another are these:

1a. Should most activities in science be teacher initiated and teacher directed?

or

1b. Should most activities be teacher initiated and pupil directed?

or

1c. Should most activities be pupil initiated and pupil directed?

2a. Should we have a structured K-6 program?

or

2b. Should we have a program made up of many unrelated units and/or activities?

3a. Should we have a product- or content-centered program?

or

3b. Should we have a process-centered program?

or

3c. Should we have a program in which pupils are provided with a variety of experiences in science which are, hopefully, interesting and intellectually stimulating with little regard for product and process learning?

4a. Should we have a program in which the objectives either are not stated or are stated in vague, general terms?

or

4b. Should we have a program in which the objectives are stated in precise or behavioral terms?

5a. Should we develop a program locally which has many of the components we value?

or

5b. Should we purchase a program which has many of the components we value?

How qualified do you presently feel to make decisions such as those above? Could you tell why you made the choices you did? Could you defend your choices at a curriculum gathering in which some persons believed differently from you?

These materials are intended to help you acquire certain cognitive understandings relative to issues such as those above. Such understandings should enable you to make more appropriate decisions in your classroom, and they should enable you to assist other school personnel to make more appropriate decisions which concern the total science curriculum in your school.

Ends and Means and Pacing Learning Activities

This exercise was written primarily for the purpose of enabling the reader to:

1. Distinguish between statements pertaining to science education according to whether they are primarily related to the ends or to the means of education.

2. Given statements from a variety of sources, indicate whether the authors of the statements have stated or implied the teacher or the pupils are to pace the learning activities.

Ends and Means

What is teaching all about? Teaching is largely decision making and carrying out those decisions. Most decisions made by teachers concern ends and means. You will surely be able to make better decisions if you are able to differentiate between ends and means. How can you change and improve your teaching (the quality of your ends and means) if you don't know the difference between the two, or if you are not sure when you make changes in your program, whether you are changing your ends, or means, or some other component of your program?

Being able to differentiate between ends and means will also enable you to better understand what you read and hear about science education. Most articles, books, and speeches about science education contain suggestions and exhortations about various components of science programs. If you know when the writer or speaker is dealing with the ends or means of education, or with some other program component, such as the pacing of learning activities, you will be in a much better position to profit from your reading and from listening to speakers and instructors when you take additional courses.

What is education all about? A not-so-profound statement concerning what it is all about is this: Students go to school to learn and grow. They go to school in order to change in some way. Most of the changes can be categorized under the headings of intellectual, social, physical, emotional, and language. Regardless of the nature of the change, or when it comes about, if it is planned for or sought after by teachers, it is considered an end of education. Ends are educational goals, purposes, aims, objectives, etc.

Changes in pupils do not happen as if by magic. Pupils must do things. They must interact with objects, books, films, ideas, classmates, teachers, etc., in order for changes to occur. As students interact with their environment, they grow, they learn, they develop. The activities in which they engage are the means through which they change.

Below are three statements. One statement is related to the ends of education, one is related to the means of education, and the other is related to both ends and means. Which is which? Number your paper from 1-3 and match the statements below with the following:

A-an ends oriented statement
B-a means oriented statement
C-both ends and means

1. Teacher A has decided he wants his pupils to learn to measure using the metric system.
2. Teacher B has decided to show his students a film about drugs so they will be able to describe the psychological effects of certain drugs on the human body.
3. Teacher C has decided his students are going to work with mealworms today.

In the first statement above, we know the change the teacher is going to promote. We know what pupils are going to learn. We do not know how they will learn. Therefore, this statement is related to the ends of education. In the second statement, we know the students are going to interact with a film (we know what the activity is) and we know why (the objective) they are going to see the film. This statement is related to both the ends and means of education. In the third statement, we do not know the objective or the change desired in pupils as a result of their working with mealworms, but we do know the activity pupils are to engage in that, hopefully, will bring about some change. Statement three relates to the means of education.

Ends, or objectives, can be stated or written, selected from books, revised, deleted, and added to.

Most of the decisions teachers make concerning ends are made when planning for teaching, not during actual teaching. For example, a teacher might sit at his kitchen table and state a set of objectives (ends) for an up-coming unit. The next morning, he might decide to delete one of the objectives from the list. Or, he might decide to change the wording of some of his objectives. A day or so later, he might be talking with another teacher and be reminded of an objective that he might add to his list. These decisions are being made prior to teaching the unit. It is likely that as the unit is implemented or taught, some modifications in the objectives will be made by the teacher. Ends are ideas or statements describing the ways in which a teacher wants his pupils to change.

Means are also planned but they are implemented or carried out. Means are activities. They usually take place during school hours when pupils are present. Some means, or activities, such as homework and field trips might take place outside of school hours or off the school grounds. Means oriented statements denote action: Read this book. Solve these problems. View that film. Construct an object. Measure the dimensions of . . . Classify the objects . . . Means are the things students do.

Ends are the changes we want to promote in students, and means are the activities through which the changes are promoted.

A teacher makes the following decisions. Is he making decisions regarding his ends or his means? Number your paper from 1-10 and respond in this manner: E-ends, M-means. The teacher decides to:

1. Invite a guest speaker to speak to his class rather than show a film strip.

2. Teach his pupils how to tell whether or not an object has moved relative to another object.

3. Use educational television each Tuesday for four weeks.

4. Increase the number of objectives relating to the characteristics and functions of cells from two to three.

5. Eliminate all of his instructional goals on the reproductive process until after the local newspaper has run the remainder of a series of articles on sex education in the schools.

6. Give slower students extra help during their "free" period after lunch.

7. State his instructional goals in behavioral or precise terms.

8. Give instructions to pupils one time and one time only!

9. During class discussions, ask more questions which require student opinion rather than recall of specific facts.

10. Use new self-help study pamphlets with slow students.

The correct responses are:

1. M - We know the activity, or means, but we do not know the objectives, or ends, the pupils are to work toward.

2. E - Here we know what the pupils are to learn (ends), but we don't know how (means) they are to learn.

3. M - See comment for number one.

4. E - Here we know the teacher had originally decided to have two objectives relating to cells and has decided to add an objective for a total of three. We have no information regarding the teacher's decision as to how any of the objectives will be met.

5. E - Some of this teacher's objectives have to do with reproduction and since the local paper is currently running a series on sex education, he has decided it is best to omit the section on reproduction until after he sees the response of the community to the series of newspaper articles. We aren't given any hint as to how (means) the teacher will teach for student mastery of his objectives on reproduction.

6. M - This statement refers to an instructional activity. We don't know what the slow students need help with or the objectives they are working toward.

7. E - This one should have been easy since the word "goals" is used. A change in the way the ends are stated is described.

8. M - Evidently this teacher's students do not pay attention when assignments are made and he has decided to do something about it. This is something one would do during instruction--during an activity. We haven't been given any information regarding the teacher's ends or objectives.

9. M - The statement "during class discussions" clearly indicates this item is related to means. (You might think this statement relates to a personal goal of the teacher. If so, you are right. But, keep in mind we are concerned with ends as they relate to goals of education or instructional goals for students.)

10. M - We know the students will be working with self-help pamphlets. We know a little about the activity they are to engage in. We do not know anything about what they are supposed to learn (the ends or objectives) as a result of engaging in the activity.

On this first practice exercise, you probably should have responded correctly to seven or more items. If you responded correctly to fewer than seven, perhaps you should reread some of the preceding material before responding to the following practice exercise.

Below are statements indicating teachers have made decisions about, or are concerned about, their ends (objectives), or their means (learning activities). Number your paper from 1-10 and match the statements with the following:

E - A statement concerning the ends of education
M - A statement concerning the means of education

1. Miss Smith decides to show a filmstrip titled "Seeds."
2. Mrs. Zirkle divides her pupils into groups of three for an upcoming activity.
3. Mr. Dodd wants his pupils to be able to develop a multi-stage classification system.
4. "Good grief! What am I going to do in science tomorrow!"
5. Mr. Tomps decides to omit his unit on soil conservation and replace it with a unit on ecology.
6. Mr. Jones assigns pages 23 and 24 in the lab manual.
7. "Oh, if my pupils could only learn the difference between mitosis and amitosis."
8. Miss Simms decides to teach her pupils how to read a Celsius thermometer.

9. Mrs. Becker asks group leaders to write the findings of their experiment on the chalkboard.

10. Miss Winfrey is much more accepting of student ideas than is Miss Belfrey.

Correct responses:

1. We know what Miss Smith's pupils are going to do (see a film); we do not know what they are supposed to learn. Means.

2. We know Mrs. Zirkle's learning activity (means) will involve pupils in small group work. We do not know the changes (ends) the teacher is trying to promote. Means.

3. We know what pupils are to learn, but we do not know how they are going to learn. Ends.

4. Here is a classic example of a teacher being concerned about his means before thinking about his ends. Do you think this is a sound idea? Means.

5. This one is difficult and you may disagree. In substituting one unit for another, the teacher is substituting one set of objectives for another. Some activities will also change and they will involve different subject matter, but such changes result from changes in objectives. Ends.

6. Pupils are to engage in the activity of completing a couple of pages in their lab book. We have no idea as to the behavior change the teacher hopes to promote through the use of the book. Means.

7. Here is a teacher concerned about his pupils not changing as rapidly and in the manner he desires. Perhaps he is not using the right means. Ends.

8. Miss Simms has decided upon an objective. Next she will have to decide on her means - the activity through which pupils will learn to read a Celsius thermometer. Ends.

9. This is a description of a small part of an actual class activity. Means.

10. When Miss Winfrey is accepting student ideas, the pupils are present and the teacher is teaching. Remember that means happen, they take place. Means.

Writers and speakers usually do not make it a point to indicate the component of the science program they are writing or speaking about. It is usually inferred or implied though, and it is taken for granted that the reader or listener is aware of the component being discussed. Being able to tell whether a writer or speaker is discussing the ends of education, the means of education, or both, or some other component is a simple but basic idea that has considerable "intellectual mileage."

All of us want to improve our science programs. To make improvements, we must make changes. In making changes, we will either change our ends (objectives), or our means (learning activities), or some other aspect of our program. It is not likely that much improvement will result unless either the ends, or means, or both are changed. If our objectives are of low priority, and if our learning activities are ineffective, that is, they do not result in the changes in pupils we seek, then changing things other than our ends and means will likely make little difference in the quality of our program.

Pacing Learning Activities

Another simple and basic idea that must be kept in mind when reading and listening to speakers and instructors concerns the pacing of learning activities. As is the case with ends and means, writers and speakers usually do not state specifically who is pacing the learning activities, but it is usually implied.

Throughout the day students engage in a number of activities. They start to read, they read, then they stop reading. They begin to work on a math practice exercise, they finish the exercise and commence a creative writing project, etc.

Who decides when pupils stop one activity and start another one? Obviously, either the teacher or the pupils make the decision.

In some classrooms, a common statement by the teacher is, "Well, it's time for math. Let's put our science books away and take out our math books. Today we are on pages 84 and 85." This is a clear indication that the teacher is pacing the learning activities.

In classrooms in which the teacher is pacing activities, all children usually do the same thing at the same time. In classrooms in which the pupils pace the activities, many different types of activities are in progress simultaneously. When the teacher paces activities, almost all children spend the same amount of time on a particular activity. Those who do not finish an activity or assignment are usually expected to finish during a "free" period or a study period, or to take the work home at night. When students pace their own activities, some spend ten minutes on an activity, some may spend twenty-five minutes on the same activity, and some might spend as much as an hour on the project. Some students might finish a project at a single sitting, and some might complete part of the project, stop and work awhile on another project, and then return to the original project for more work.

Let's assume a group of students are to learn ten different things by engaging in ten different learning activities. If all students learn the first thing, then all learn the second, etc., and all finish number ten at the same time, this is teacher-paced, or group-paced instruction. If students are permitted to work through the ten activities as rapidly or as slowly as their interest and ability permit, some will finish the ten tasks in a few days, some in a week, and some may take as long as two or three weeks to finish. When students are pacing their own learning activities, they are "strung-out" through the program with few students working on the same activities at the same time.

One decision that you must make in teaching science is when you will pace activities, and when you will permit or enable your pupils to pace their own activities. Another decision you will have to make is in selecting and developing curriculum materials that permit the type of pacing you believe in. As you probably know, most of today's teachers pace their pupils' activities. Do you think they have decided to do this after carefully considering the merits of teacher-pacing and pupil-pacing, or is it because they do not know how to use a teaching strategy in which pupils pace their own activities, or because they do not have curriculum materials designed for student pacing?

This is an interesting question, but let's get back to our main concern--helping you to identify statements from which one could make an inference as to whether the teacher or the pupils are pacing activities.

Below are two statements or quotes from a science program.

Does either quote contain information that would allow us to infer whether the teacher or the pupils pace the learning activities?

1. "Select two rods of the same shape. One should be a good thermal conductor and the other a poor one--for example, a glass rod and an aluminum rod. Light two alcohol lamps and ask the class to observe closely as you hold the rods in the flames."

2. "By identifying component capabilities for each science process, it is possible to provide a rational and sequential ordering of capabilities which the child may be expected to acquire through the activities of the program."

If you are having trouble deciding, here are some questions to ask concerning the statements: Are all children likely doing the same thing? (This is an indication the teacher is pacing activities.) Is there a clue as to whether the children have a choice as to when they perform the activity? (If so, the pupils are likely pacing their activities.) Only one of the statements--the first one--permits us to make an inference concerning who is pacing activities in the program. In the first statement, the teacher is instructed to "ask the class . . ." This is a clear indication that in the series of lessons from which this quote was taken, all pupils are engaging in the same activity; therefore, the teacher is pacing activities. In the second statement, although there is reference to ". . . the child . . .," no information is given that would permit us to make an inference concerning the pacing of activities.

Below are quotes from various science curriculum materials and books on science education. Number your paper from 1-10 and place a T by the number of each quote in which the authors have implied the teacher is pacing the activities and place a P by the number of each quote in which it is implied the pupils are probably pacing their own activities. If you are unable to infer who is pacing the activities, leave the space blank.

1. "Show the class a bicycle wheel or another round object 30 centimeters or more in diameter."

2. "It takes most children from two to five hours to complete these exercises."

3. "Lessons in which you define a new term are called invention lessons."

4. "Each of the new programs proposes that the children should directly use the equipment and materials necessary to carry out experiments and other investigations in science."

5. "After . . . (the teachers) distributed the bottles and other materials . . ., each table (accommodating four or five children) had the following items:"

6. "A primary grade teacher wants a class to learn some safety standards for bus travel. The children are asked to observe the demonstration to tell what happened and why."

7. "The activities in Mystery Powders deal with the properties of various substances and the use of indicators in detecting their presence."

8. "You can use preliminary exploration time as a means for obtaining a picture of the understanding and prior experience possessed by the group and individuals in it, regarding the phenomena they are beginning to study."

9. "Questions and comments tumble out as children work with sand. Almost every child seems to know something about sand, whether or not he has played in a sandbox or gone to a beach."

10. "To initiate the activity, show the students a 'closed system' which you have already constructed."

Correct responses:

1. The key term here is "the class." If the class is engaging in an activity, the chances are great that the teacher told students when to begin the activity and will be the one to decide when the activity will stop. (T)

2. If all children complete the exercises and it takes some two hours and some five hours, the chances are that the pupils are pacing their own activities. If the teacher was pacing the activities, all pupils would probably spend the same amount of time on the exercises, and some would finish and some would not. (P)

3. "Lessons" usually means the teacher is directing all pupils. (T)

4. Do we have information that enables us to infer whether children use equipment and materials when they want to or when the teacher wants them to? No, we do not. You should not have responded to this item.

5. Here is a description of a classroom set up for small group work under the direction of the teacher. Since each table had the same items, it is probable that each group will be doing much the same thing at about the same time. (T)

6. It seems that all children must observe a single demonstration that is probably being conducted at the front of the room. If all children are doing the same thing at the same time, the teacher is pacing the activities. (T)

7. The activities in a unit are described. No reference is made to children working with the activities or to anything else that would enable us to infer who is pacing the activities.

8. " . . . the group . . ." and " . . . they . . ." indicate the author of this statement is assuming the teacher is to pace learning activities. (T)

9. This tells us that most children know something about sand and that they have questions and comments as they work with it. We do not have any information that would allow us to infer whether children work with sand when they want to or when the teacher wants them to.

10. The teacher is about to commence an activity that evidently involves all of the students. If this is the case, we infer the teacher is pacing the activities. (T)

Pacing refers to the rate students proceed through a series of activities and to whether the rate is determined by the teacher or pupils. Do not confuse the pacing of activities with the selection of the activities. If students pace their activities, it does not automatically follow that they are free to do anything they wish. If the teacher selects the ends and means but permits pupils to pace the means, the pupils must still do what the teacher has prescribed, but they have freedom to proceed at their own pace. Some persons consider this to be one type of individualized instruction. Other persons do not consider instruction to be individualized if all pupils learn the same things in the same way but some pupils are allowed to proceed faster or slower than other pupils.

Since you are largely responsible for making the decisions in your classroom, you must decide whether you or your pupils will pace their learning activities. Once you have made this decision, you will need to obtain or develop curriculum materials that lend themselves to the type of pacing you have chosen. As you have seen in the quotes above, one can usually determine whether curriculum developers intend learning activities be paced by the teacher or by the pupils.

Let's assume you are interested in learning more about students pacing their own activities and are interested in examining curriculum materials which permit student pacing. Number your paper from 1-5 and place an "X" by the items below in which you would be interested in reading more about (because they imply students are to pace their own activities).

1. The first part of the children's colloquium is a pooling of observations, getting a collection of facts in the arena, so to speak . . . . A circular arrangement of chairs is an obvious aid here. Instead of focusing on the backs of their colleagues' necks and the teacher's authoritative face at the front of the room, the children look into each other's faces when they talk.

2. The student plays a very important part in the evaluation of his progress--he helps decide the quality, extent, and rapidity of his learning. And, with INDIVIDUALIZED SCIENCE, the student spends most of the time working independently. He soon discovers that learning--not just scientific learning, but all learning--can be a self-directed, self-initiated activity.

3. If the teacher is not to stand at the learner's elbow "cracking the whip," the learner must take increased responsibility for his own learning activities. He must develop a new sense of responsibility for mastering material without someone always telling him when he has done the work and when he has completed an activity.

4. The model has to operate, if it is to do so successfully, with clearly defined learning objectives devised by the teacher. It is essential that (1) these objectives be multiple, flexible in that children can meet them when they are ready to do so; (2) that the learning situation offer alternatives to children for meeting these objectives.

5. What are some of the indicators that can be used to make judgments concerning the pacing of lessons? One of the tasks that a teacher is constantly faced with in working with children is that of determining when the class is ready to go on to a new lesson. If she goes on to a new lesson too quickly, the objectives of the lesson may not be achieved, and the children may not have achieved the optimum benefit from the lesson. This may prove to be a handicap in subsequent lessons. If the pace is too slow, children may get bored, valuable time may be wasted, and discipline problems may arise. Of course, it should be remembered that children do not all learn at the same rate and they do not all have the same attention span.

If you are interested in learning more about students pacing their own activities, you would probably like to read more in the sources of statements two, three, and four. Persons interested in learning more about teaching science using a strategy calling for teacher pacing of learning activities would probably be interested in the sources of statements one and five.

Summary

Being able to differentiate between ends and means and between teacher-paced and student-paced learning activities, are two simple but essential skills that both preservice and inservice teachers should possess. These skills are extremely useful in reading professional literature, in listening to speakers and instructors, and in making decisions concerning teaching and in selecting, developing, and implementing curriculum materials.

Ends and Means and Pacing Learning Activities

Objective 1 - Pretest

Match the teacher decisions below with the following:

E - a decision concerning the ends of education
M - a decision concerning the means of education

A teacher decides to:

_____ 1. Take his pupils on a field trip.
_____ 2. Teach his pupils how to prepare a slide for viewing with a microscope.
_____ 3. Eliminate some of his content goals and add process goals.
_____ 4. Use slides to show his pupils what certain objects in outer space look like.
_____ 5. Explain to his pupils that pollution in one community sometimes affects other communities.
_____ 6. Develop pupils' ability to graph data using a histogram.
_____ 7. Stop requiring students to memorize the definition of new science words.
_____ 8. Teach students to match early theories on matter with the scientists who proposed the theories.
_____ 9. Show location of current weather fronts with overhead projector.
_____10. Increase the number of goals in his unit "Ponds, Lakes, and Streams" from eleven to fourteen.
_____11. Suggest that a child who is a poor reader join a small discussion group to get the information he needs for a particular objective.
_____12. Change from teacher-pacing to student-pacing of learning activities.
_____13. Develop a set of instructional materials to be used in independent study.
_____14. Reduce the number of instructional objectives concerning ecology from nine to seven.
_____15. Choose two students to manipulate equipment during an upcoming demonstration.

Ends and Means and Pacing Learning Activities

Objective 2 - Pretest

Indicate by each statement below (some of which were selected from science teachers' manuals and other materials) whether the authors of the statements state or imply the teacher or the pupils are pacing, or are expected to pace, the learning activities by placing a T (for teacher) or P (for pupil) in the spaces provided.

____ 1. Only about three sets of materials are needed in any one room since children will be working with these and other materials at different times.

____ 2. Students should be permitted to delete activities they feel are not necessary for them to complete in order to achieve the objectives.

____ 3. Whenever a child demonstrates mastery of an objective he either proceeds with the next task in that series or he continues with work on some other project.

____ 4. You may like to think of each lesson as having three main parts. In the introduction you refer to a current incident involving your pupils or to a preceding experiment to set the stage for the activity. The children's reaction will help you decide whether they need further review of previous activities before you present new ones.

____ 5. To encourage original investigation, avoid providing any more information than is necessary for the proper conduct of the lesson. Be alert for questions that are really worth pursuing. Do not push for solutions beyond the comprehension of the children.

____ 6. The Classroom Laboratory for the . . . series is a practical way of converting an ordinary classroom into a classroom laboratory. It is built around the concepts of the science curriculum; it anticipates and solves the problems of classroom management; and is designed to be used with the entire class.

____ 7. Before you start Activity 1, make sure that all groups have properly operating circuits. The children should be able to state that if the lamp glows, the circuit is closed; if the lamp does not glow, the circuit is open.

____ 8. . . . many teachers prefer to leave the boxes of cards in a special place where a few children can come to them at will, in their free time. This approach is recommended.

____ 9. After the students have discussed what they might use as containers to hold the gas, show them a plastic bag, and ask how they can weigh air using the bag, a tie band to seal off the bag, and their balances.

____10. A class of 30 pupils, for example, may be divided into six groups of five pupils, with each group performing the same investigations. There are also materials for the performance of numerous individual activities which may be used as teacher or committee demonstrations.

Ends and Means and Pacing Learning Activities

Objective 1 - Post-test

Match the teacher decisions below with the following:

E - a decision concerning the ends of education
M - a decision concerning the means of education

A teacher decides:

_____ 1. To expect students to be able to describe five ways in which water is essential to man.
_____ 2. To divide his pupils into groups of three for an upcoming activity.
_____ 3. To use the overhead projector to show a graph containing data about the number of peas in pods.
_____ 4. To show the filmstrip "How We Get Our Food."
_____ 5. To state precise goals for an upcoming unit.
_____ 6. To teach his pupils to differentiate between symmetrical and nonsymmetrical objects.
_____ 7. He wants his pupils to be able to construct at least three inferences based upon an observation.
_____ 8. To institute a plan whereby pupils serve as tutors to other pupils.
_____ 9. To rotate materials among groups of students at fifteen minute intervals.
_____ 10. To make science more informal and unstructured by using interesting and provocative materials which lend themselves to manipulation and exploration.
_____ 11. To invite the school nurse to speak to class.
_____ 12. To demonstrate to students how the patterns of the lines of force of a magnet can be viewed.
_____ 13. To eliminate objective three which concerns human reproduction.
_____ 14. To assign an outside reading for more able pupils.
_____ 15. To be more precise in stating instructional intents.

Ends and Means and Pacing Learning Activities

Objective 2 - Post-test

Indicate by each statement below whether the authors of the statements state or imply the teacher or the pupils are pacing, or are expected to pace, the learning activities by placing a T (for teacher) or P (for pupil) in the spaces provided.

____ 1. As you circulate among the groups and join each one for a few minutes, you will determine how familiar the children are with the concepts of interaction, systems, and evidence of interaction.

____ 2. The blocks can be used in a number of different ways. For example, you can leave them out for the students to use if, when, where, and for whatever reason they choose.

____ 3. When the student decides that he has achieved the instructional objectives of a module, he asks his teacher to allow him to challenge the module test.

____ 4. Children should be allowed to proceed at their own rate. They should feel free to work alone or in groups; to charge ahead or to repeat one set (of cards) several times if they like.

____ 5. With the children seated in a circle on the floor or in chairs, where objects are easy to see and can be passed with little difficulty, begin by asking, "How can you find out about these objects?"

____ 6. For the first period, each pupil will use only a battery, a light bulb, and one piece of insulated wire. Arrange these materials on the trays. The same items, as well as a bulb holder and a brass clip, will be needed by each child at the beginning of the second period.

____ 7. You can illustrate the meaning of models by using the following analogy. Ask the class how many of them know how to play rugby. Most likely very few children have ever heard of the game.

____ 8. Discuss the general topic of training animals with the class. The discussion will vary from class to class; you do not need to follow in detail the questions suggested below. The children may suggest a variety of activities that would allow them to study the "learning" process in guinea pigs.

____ 9. The materials can be kept in a specific place in the classroom, and the children can come to them when they have time available . . . Depending on their interest, they will want to spend anywhere from a few minutes to hours at a time with the materials.

____10. There are several ways of initiating the entire unit. Sometimes a previous unit will lead the children quite naturally into a new unit. If the class has just finished a study of magnets, for example, it will require very little effort to motivate the children for the study of electromagnets.

Alternative Approaches in Elementary Science Education

This exercise was written primarily to enable the reader to:

1. Given statements describing various situations, and statements from the professional literature, indicate:

   A. Whether the teacher or pupil(s) is/are likely determining or selecting the ends in the situations described.
   B. Whether the teacher or pupil(s) is/are likely determining or selecting the means in the situations described.
   C. Whether the teacher or pupil(s) is/are likely pacing the instructional or learning activities in the situations described.
   D. Whether pupils are receiving instruction or teacher guidance individually, in small groups, or in a large group.

2. Describe the approach to elementary science education that you tend to favor at this time and explain why you favor the approach by:

   A. Stating whether you believe the teacher or pupils should have primary responsibility for identifying or selecting the ends, or objectives, and listing two reasons why you believe as you do.
   B. Stating whether you believe the teacher or pupils should have primary responsibility for identifying or selecting the means, or learning activities, and listing two reasons why you believe as you do.
   C. Stating whether you believe the teacher or pupils should pace the learning activities and listing two reasons why you believe as you do.
   D. Stating whether you believe pupils should receive instruction or teacher guidance individually, in small groups, or in one large group and listing two reasons why you believe as you do.

If you were asked to name as many approaches to science education as you can, how many could you name? Approaches go by many names--some of them are: the textbook approach, the laboratory approach, the lecture-discussion approach, the problem-solving approach, subject-matter or content approach, computer-assisted instruction, the instructional technology approach, conceptual schemes approach, inquiry approach, process approach, individually prescribed instruction (IPI), the open classroom approach, and we sometimes read about a "messing around" approach.

Most labels tell us very little about what is taking place in the school program. In classrooms in which many of the above approaches are supposedly being carried on, we do not know whether the teacher or the pupils have major responsibility for making basic educational decisions.

A relatively simple way to describe approaches to education so that we do have an idea as to what is taking place in the classroom is in terms of who makes basic decisions, that is, in terms of whether the teacher or pupils identify or select the ends and means and pace the learning activities, and in terms of whether pupils receive teacher assistance individually, in a small group, or in one large group.

As a teacher, you must make these decisions. The decisions directly concern the amount of freedom you will give your pupils and the amount of responsibility they will assume for their own learning. It has been said that as students are given more freedom and assume more responsibility for their own learning, they become more independent learners and less dependent upon the teacher.

It is quite obvious that all school programs involve ends and means of some kind. Since ends and means do exist, they must originate with someone. In most classrooms, they either originate with the teacher or with the pupils. Our major alternatives with respect to how they originate are these:

1. The ends and means are stated, selected, or planned by the teacher and imposed upon pupils--pupils learn primarily what the teacher wants them to learn, and they learn the way the teacher wants them to learn.

2. The ends and means are "identified" by the pupils--pupils learn primarily what they want to learn with the materials made available by the teacher. (By controlling learning materials, the teacher indirectly effects what the ends and means will be.)

3. A number of ends and means are made available to pupils by the teacher and pupils are permitted to select from among the alternatives.

4. The ends and means are cooperatively developed between the pupils and teacher--they "negotiate" with the result being some of the things the teacher thinks are important are included and some of the things the pupils are particularly interested in are included.

As decisions are made as to who (teacher or pupils) is to decide what children learn, and who is to decide how they learn, some thought should be given to when they are to learn. For some reason most children in today's schools are expected to learn the same thing at the same time. This results when the approach used calls for the teacher to select the ends and means, to pace instructional activities, and to provide instruction to pupils in a large group. Another alternative with respect to pacing is to permit pupils to pace their own activities (and for the teacher to provide assistance individually or in small groups). A third alternative is for the teacher to set a deadline and to permit pupils to work at their own speed within the deadline. Our major alternatives with respect to the pacing of learning activities then are:

1. The teacher paces the activities.

2. Each pupil paces his own activities.

3. The teacher sets a deadline and pupils are free to proceed at their own pace as long as they are completed by the deadline.

Regardless of who selects the ends and means and who paces the activities, the teacher is expected to provide assistance or guidance to pupils as they work. There are three major alternatives:

1. The teacher provides assistance to all pupils at the same time--large group instruction.

2. The teacher provides assistance to small groups of pupils--those who are working on the same things and who need the same type of help.

3. The teacher provides assistance to pupils individually.

If we have four major alternatives with respect to who selects the ends, four alternatives with respect to who selects the means, three major alternatives with respect to who paces the activities in which pupils engage, and three major alternatives with respect to whether pupils receive teacher guidance individually, in small groups, or in a large group, theoretically we have 4x4x3x3 or 144 possible approaches or alternatives from which to choose. (However, some of the approaches are rather unusual or ridiculous.)

Some of the alternative approaches are:

	Selects Ends	Selects Means	Paces Activities	Pupils Receive Guidance
1.	Teacher	Teacher	Teacher	In large group
2.	Teacher	Teacher	Pupil	Individually
3.	Teacher	Pupil	Pupil	Individually
4.	Pupil	Pupil	Pupil	Individually
5.	Pupil	Teacher	Pupil	In small groups*

*One of the unusual or ridiculous alternatives.

Most persons, in speaking and writing about science in the elementary school, seem to be concerned with improving the support system (instructional materials, teaching strategies, classroom management techniques, etc.) for the traditional approach in which the teacher selects the ends and means, paces learning activities, and provides instruction to all pupils at one time (Number 1 above). Support systems have not evolved which make possible at this time effective implementation of many of the alternatives. However, the teacher-centered, large-group approach is being questioned by some persons and some of the other approaches are gaining considerable attention.

One approach that is quite different from the traditional approach is that known as "open education," "integrated day," and "informal classroom"--plus a few other labels. Some of the assumptions upon which this approach is based are:

1. Children have both the competence and the right to make significant decisions concerning their own learning.

2. Children will be likely to learn if they are given considerable choice in the selection of the materials they wish to work with and in the choice of questions they wish to pursue with respect to those materials.

3. Confidence in self is highly related to capacity for learning and for making important choices affecting one's learning.

4. Children learn and develop intellectually not only at their own rate but in their own style.

5. Little or no knowledge exists which it is essential for everyone to acquire.[1]

Statements one and two above clearly relate to the selection of the ends and means of education, and statement four relates to the pacing of learning activities. Persons who believe in the above statements obviously believe children should have a greater hand in determining their school program than most children now have.

Billings referred to the classroom situation or approach in which children have primary responsibility for making basic decisions regarding their program as the "self-selection" classroom. She stated:

> . . . if you agree that all children can and want to learn, all children can identify real purposes for learning, all children can learn to identify their needs, all children can be self-directing in their learning, all children can learn to evaluate their own learning, then, self-selection may be for you.[2]

Rogers, after describing the attitudes he thought teachers should hold, made it very plain as to who he thought should have major responsibility for making the basic decisions in the classroom when he wrote:

> If I distrust the human being then I must cram him with information of my own choosing, lest he go his own mistaken way. But if I trust the capacity of the human individual for developing his own potentiality, then I can provide him with many opportunities and permit him to choose his own way and his own direction in his learning.[3]

The issue that probably divides people with respect to whether the teacher or pupils should have major responsibility for selecting the ends and means and pacing learning activities is that of whether or not children want to learn. Billings and Rogers are among the many persons who believe that, if the conditions are right, children do want to learn. There are many other persons, though, who believe as Bruner, and think that not all children will learn if given the freedom to choose. Bruner indicated that his book, The Process of Education, was:

> . . . based on a formula of faith: that learning was what students wanted to do, that they wanted to achieve an expertise in some particular subject matter. Their motivation was taken for granted.[4]

Bruner went on to say that failure to question this and other assumptions had caused much grief.

Learning to teach science has been made more difficult in the past few years with the advent of different approaches to education. A decade ago, most teachers were supplied with a textbook for each child and a teacher's manual. Science was either taught from the text or from a teacher-constructed unit with supplementary materials such as films and materials available locally. Most teachers and teacher educators more or less accepted the notions that what children learned was largely determined by the teacher (or textbook), that the way children learned was largely determined by the teacher, and that all pupils learned much the same thing in the same way and at the same time. In other words, the teacher selected the ends and means and paced the learning activities.

While this approach is being questioned by a number of persons, it is still an alternative available to today's teachers.

Inasmuch as there are many alternatives available to today's teachers, it is believed that when you study science education, you should be aware of which alternative is being considered.

Most persons, in writing and talking about science education in the elementary school do not indicate which approach (in terms of who selects the ends and means and who paces the learning activities, etc.) they are referring to. It seems they take it for granted the approach they are referring to is the approach--the way it is or should be done in elementary classrooms. However, it is usually possible to infer the approach being discussed or used from a few key statements. For example, when a teacher remarks, "If I tell my students to take out their books and open them to a certain page, at least five of them will ask to have the number of the page repeated. They just don't listen anymore!" This is a good indication that the teacher is selecting the ends and means, pacing learning activities, and is providing large group instruction. Obviously, a teacher who makes such a statement does not intend to reveal the approach he is using.

How good are you at "reading between the lines"? Suppose a new teacher in your school asks you, "Do you think anyone would object if I waited until the end of the year to teach the Energy unit? It's the second chapter in our text, but I would rather wait on it." Which alternative has the teacher selected? It appears the teacher is going to teach the unit to her pupils. If she is going to teach all of them something at the same time, she is likely selecting the ends and means and pacing the activities, and providing large group instruction.

Below are some situations, comments, etc. Number your paper from 1-10 and place four short lines after each number--like this.

1. ____ ____ ____ ____

2. ____ ____ ____ ____

On the first line after each number indicate who is likely selecting the ends or objectives by placing a T (for teacher) or P (for pupil). On the second line after each number, indicate who is likely selecting the means or learning activities by placing a T or P on the line. On the third line, indicate who is likely pacing the learning activities by placing a T or P on the line. And, on the last line after each number, indicate whether the teacher likely provides instruction or assistance to individual children (use I for individual), to children in small groups (use S for small group), or to all children as one large group (use L for large group).

1. Children in Miss Deckard's room are free to do anything they wish in science as long as Miss Deckard believes the activity is profitable.

2. From a book: Whether the teacher is new or experienced, she will derive considerable self-confidence when she goes into the classroom with a well-planned lesson. By contemplating as many factors as she can before entering the classroom, she can minimize or eliminate potential discipline problems and learning difficulties.

3. A glance at Miss Rooker's room reveals that only three students are at the science interest center. Two pupils are working with balances and the third is observing two white mice exercising on the wheel in their cage. Other pupils in the room are at other centers (reading, art, math, etc.) and are engaging in a variety of activities.

4. As a homework assignment, all of Mrs. Klutz's pupils are to observe the moon on three successive nights and plot its location on a chart provided by her.

5. Joan has completed two-thirds of the prescribed science program. At the rate she is working, she will be the first in her room to complete the program ordinarily associated with her grade. She will complete the program by the end of the sixth month of the school year.

6. Miss Smith tells her pupils to read the next two pages and they will discuss them when most have finished.

7. Jill was in the process of experimenting with mealworms and was keeping accurate records of her work. She stopped her work with mealworms because of lack of interest and commenced to prepare slides of microscopic organisms and viewed them under a microscope.

8. Mr. Levitt has each of his pupils to construct a color wheel that, when spun, turns a color that is different from any actual color on the wheel. He then asks pupils what is meant by "visual consistency."

9. Jim is the only student in his class who is working on a display of fall leaves. He is naming each and grouping them based on similarities and differences. His teacher tells him to try to be finished by Tuesday of next week so his work can be displayed at open house.

10. Statement from a teacher's manual: "Have the children read page 8 and observe the pictures at the top of the page. Then ask these questions . . ."

Correct responses:

1. PPPI - The pupils are selecting their own activities and, therefore, their own ends. If pupils select different things to do and work on, they must be pacing their own activities. In such a situation it is necessary that the teacher assist pupils individually.

2. TTTL - If one is "going into the classroom" or before a group of pupils with a lesson well planned in advance, he very likely has included in his plan ends and means or objectives and activities. It is highly probable under such circumstances that all pupils will learn the same thing at the same time. If so, the teacher is pacing the activities and is providing large group instruction.

3. PPPI - Students in this room are evidently free to make choices and decisions regarding what they learn (at least during certain periods of the day). It appears the pupils have been given freedom to decide what they will learn and how they go about it. They are probably free to work at their own pace, also. If they need assistance, it will be provided individually.

4. TTTL - If all students have the same homework assignment they are evidently studying the same thing at school. If they are all studying the same thing, it is highly unlikely they were free to select their ends and means and all chose the same thing.

5. TTPI - Since Joan's program is prescribed, the teacher is likely selecting both the ends and means. Since she will be the only student to finish the program when she does, she must be pacing her own activities. Since she is far ahead of her classmates, instruction would have to be provided individually.

6. TTTL - Another case of all pupils doing the same thing at the same time with all decisions being made by the teacher.

7. PPPI - It seems Jill was free to stop one project and begin another when she wanted to. If this is the case, she is selecting her own ends and means and pacing her activities. When students do these things, the teacher must provide help individually as students require it or seek it.

8. TTTL - See No. 6 above.

9. PPTI - Probably the only point of possible disagreement here would be in who is pacing the activity. Since the teacher has set a deadline for Jim, he is no longer free to proceed at his own pace to the extent he might have been without the deadline. This is a combination of teacher and pupil pacing.

10. TTTL - If all pupils are to read the same page, observe the same pictures, and are asked the same questions by the teacher, the traditional approach in which the teacher selects the ends and means, paces learning activities, and provides large group instruction is being referred to.

In years past, it has been more or less taken for granted that the teacher selects the ends and means, paces activities, and provides large group instruction all amid an occasional plan to "provide for individual differences." Most instructional materials available today, especially commercially prepared materials, have been developed with this approach in mind. Today this approach is being questioned and new teaching strategies are evolving. Accompanying instructional materials are becoming available. Which of the many approaches are best? How much freedom should pupils have in regard to their school program? How much responsibility should they assume for their own learning? How much responsibility can they assume?

In most schools, teachers are relatively free to use the approach that fits their teaching style and that is consistent with their philosophy. Which approach do you think is best, that is:

1. Should the teacher or pupils have primary responsibility for selecting the ends or determining what pupils learn in science? Why do you believe as you do?

2. Should the teacher or pupils have primary responsibility for selecting the means or learning activities? Why do you believe as you do?

3. Should the teacher or pupils pace learning activities? Why do you believe as you do?

4. Should teacher guidance and instruction be provided individually, in small groups, or in one large group? Why do you believe as you do?

Why do you believe as you do--what are your reasons? Below are some students' responses to this question and the four above. Do you believe all four questions above were answered, or was some other question answered in some cases?

> I favor the "Discovery Method" for science education. The overall objectives are selected by the teacher, but the children help to decide the means by which the objectives will be reached. The children pace their activities and may have any group arrangement or work independently.

Does the comment about the "Discovery Method" tell us anything? Who does this person think should select the ends? The means? Who should pace activities? These questions are answered, but do you see any statement that could serve as a reason why this person believes as he does? A second student responded in this manner:

> I would tend to choose the teacher to select the ends and means and pace the activities of the class. This is probably due to tradition and my lack of knowledge of the other approaches.

This student's last comment is his reason for believing as he does concerning who should select the ends and means and pace learning activities. This statement is more acceptable than the first one above. A third student responded in this manner:

> The ends or goals should be set up by the teacher. Through guidance by the teacher, individuals, or small groups should be allowed to work at their own pace. Experimental stations, investigation kits and various reading material should be made available to students to work on through the school day. A unit can be presented by the teacher and goals can be discussed with the students. Then they can manipulate materials or can read for information needed so they can reach the pre-determined goals they and the teacher have previously discussed.

This person tells us quite clearly who should select the ends and means and pace learning activities, but instead of giving reasons why he preferred this approach, he described how the approach might be implemented. He answered the wrong question! This student's response is not as acceptable as the second student's response. A fourth student responded in this manner:

The teacher should select the goals and provide the means (experiences) by which a child may learn the things to be mastered. The child should do the work at his own pace. I favor this approach for the following reasons:

1. Realistically speaking, children do not have the background to choose what should be learned.
2. Sometimes there will be some real sharp students who can look ahead and really wonder about something.
3. If left to choose, a student might pick something too hard and it would be a waste of his time.
4. Many times students aren't aware of subject matter fields enough to set a realistic goal.
5. A child will be more apt to learn if he is interested in the material and he is able to work at a successful level.

Can you determine whether the "reasons" above are related to ends, means, or pacing of learning activities. It seems to me statements one, three, and four concern ends. I believe statement two is irrelevant and statement five might be more appropriate if this student had indicated the student was to select the ends and means. Has this student indicated why he thinks the teacher should select or determine the means? Has he indicated whether children should receive teacher guidance individually, in small groups, or in a large group?

Who do you think should select the ends or objectives of science education? What are two reasons why you believe as you do?

Who do you think should select the means or learning activities in science? What are two reasons why you believe as you do?

Who do you think should pace science learning activities? What are two reasons why you believe as you do?

Should children receive instruction and teacher guidance in science, individually, in small groups, or in a large group? What are two reasons why you believe as you do?

References:

1. Roland S. Barth, "So You Want to Change to an Open Classroom," *Phi Delta Kappan*, LIII (October, 1971), 98-99.
2. Zilpha W. Billings, "Self-Selection Classrooms," *Today's Education*, LIX (October, 1970), 16.
3. Carl Rogers, *Freedom to Learn*, (Columbus, Ohio: Charles E. Merrill Pub. Co., 1969), p. 114.
4. Jerome S. Bruner, "The Process of Education Revisited," *Phi Delta Kappan*, LIII (Sept., 1971), 19.

Alternative Approaches to Elementary Science Education

Objective 1 - Pretest

In each situation described below, indicate in the spaces provided:

A. Who is likely stating or selecting the ends (T-teacher; P-pupil).
B. Who is likely stating or selecting the means (T-teacher; P-pupil).
C. Who is likely pacing the learning activities (T or P).
D. Whether teacher guidance is provided individually (I), in small groups (S), or in a large group (L).

_ _ _ _ 1. From an article: "Children are free to move about the room, talk to anyone, or explore the centers until they find some project with which they can become really involved."
A B C D

_ _ _ _ 2. Miss Klinker remarked to a fellow teacher: "You have to plan a lesson for tomorrow! Good grief, I haven't planned a science lesson in two years. I do construct pretests and instructional modules and post-tests, but no lesson plans. That reminds me, I have to get my pretest ready for the next unit. We are about to finish a unit."
A B C D

_ _ _ _ 3. Pupil to teacher: "Mrs. Bipple, I took the pretest for observation/inference 3 and missed all of them. I just don't understand it."
A B C D

_ _ _ _ 4. Adapted from an article: "Give children the opportunity to choose from a variety of materials of interest to them, to work individually, with a partner, or in small groups, and to make their own decisions about when to work on what..."
A B C D

_ _ _ _ 5. From a teacher's manual: "Let him handle equipment, observe, think and draw conclusions on his own. Let him work in the regions of his own interest and to a depth he determines appropriate. Teachers will find it very difficult to act only as a resource person and not to impose their own extrinsic guidelines and limits."
A B C D

_ _ _ _ 6. Teacher to pupils: "Please clear your desks and take out your science books and open them to page 134."
A B C D

_ _ _ _ 7. Tim is learning to identify simple machines. When he can demonstrate mastery of this competency, he will learn how to identify the faster gear on an object with two gears. He is the only student in his room who is working on this particular skill.
A B C D

A B C D 8. Judy and Martha are collecting information about human diseases. Later they will report to interested classmates what they have found. After their report Judy has decided she will work with Sally on a project involving fossils. Martha is undecided as to what she will do next, but thinks she will study viruses.

A B C D 9. Miss Mullins is conducting a demonstration to show that matter has weight. Most of her pupils observe intently.

A B C D 10. Teacher handing back test papers: "Some of you didn't do very well on this unit. I hope to see some improvement in our next unit."

Alternative Approaches to Elementary Science Education

Objective 2 - Pretest

In each statement below, underline your choice of the words in parentheses and then state two reasons for each of your choices in the spaces provided:

A. I believe the (teacher, pupil) should have primary responsibility for stating or selecting educational ends or instructional objectives in science because:

1____

____

2____

____

B. I believe the (teacher, pupil) should have primary responsibility for selecting or planning educational means or learning activities in science because:

1____

____

2____

____

C. I believe the (teacher, pupil) should pace most learning activities in science because:

1____

____

2____

____

D. I believe the teacher should provide pupils with assistance and guidance (individually, in small groups, in one large group) because:

1 ______________________________

____

2 ______________________________

____

Alternative Approaches to Elementary Science Education

Objective 1 - Post-test

In each situation below, use a T, P, and I, S, or L to indicate:

A. Who is likely stating or selecting the ends (T-teacher; P-pupil).
B. Who is likely stating or selecting the means (T-teacher; P-pupil).
C. Who is likely pacing the learning activities (T-teacher; P-pupil).
D. Whether teacher guidance is provided individually (I), in small groups (S), or in a large group (L).

_ _ _ _
A B C D
1. From a teacher's manual: "Your first lesson on material objects will be rather formal. Present classroom objects such as chalkboard erasers, books, chairs, and goldfish, and ask the children to tell you about them. Use the term object in your discussion."

_ _ _ _
A B C D
2. Adapted from a new program brochure: "The . . . materials must follow the instructional objectives and must allow the student to advance independently with a minimum of teacher instruction. Each set of materials must be identified as teaching some specific objective. The student works with little teacher assistance by using workbooks, programmed materials, recorded lessons, and instructions."

_ _ _ _
A B C D
3. Teacher to pupils: "When all of you have finished reading this section, we will do the experiment at the end."

_ _ _ _
A B C D
4. From a "methods" book: "Whenever possible, let the children do the experiment or demonstration themselves. If this procedure is not advisable, one or more children can assist the teacher. This privilege should be rotated so that all the children will have an opportunity to participate. In those cases where, for various reasons, the experiment or demonstration is performed by just one or two persons, the teacher should always keep in mind that it is being given for the benefit of all the children."

_ _ _ _
A B C D
5. Tom: I need help.
Teacher: Which unit are you working on?
Tom: Three B. I don't understand what this says.
Teacher: What is your objective?
Tom: Well, it says, "Be able to summarize information about a given issue from a variety of sources."

$\overline{A}$ $\overline{B}$ $\overline{C}$ $\overline{D}$ 6. Adapted from a new program brochure: "The teachers at Parkview had been successful in adapting commercially available workbooks into individualized instructional materials. The school buys two copies of each manufacturer's workbook and copies of the teacher's manual corresponding to the workbook activities. Each sheet from the workbooks can then be mounted on a heavy piece of cardboard. Next, they take the workbook apart, mounting each sheet and numbering them according to some system of concepts. These sheets are then placed in a box. The students are given complete lists of the concepts on an individual score sheet. They do not have to proceed in any sequence or at any fixed rate."

$\overline{A}$ $\overline{B}$ $\overline{C}$ $\overline{D}$ 7. Adapted from a new program brochure: " . . . students are free to select learning activities on their own . . . a pupil is given a wide range of materials from which to select something he thinks is appropriate for achieving his prescribed objective. Teachers report that 90% of the time the children select correctly."

$\overline{A}$ $\overline{B}$ $\overline{C}$ $\overline{D}$ 8. From a new program brochure: "You will observe that each exercise in the text begins with a clear statement of objectives, which are expressed in terms of children's performances. The objectives are simple statements of what the individual child is expected to be able to do after successful completion of the exercise, and in this sense the objectives are properly called behavioral objectives or behaviors. Effective methods for testing the achievement of the children have been built into the program. The Group Competency Measure is a means of evaluating the entire class membership at one time."

$\overline{A}$ $\overline{B}$ $\overline{C}$ $\overline{D}$ 9. From a "methods" book: "The teacher can best show his willingness to be an investigator during the time that data are being interpreted. When data are available for inspection and evaluation, they must be arranged in an order which will allow all the children to view them at the same time. A technique which is quite useful to allow data to be efficiently displayed and to allow the teacher to become a part of the investigation is for him to use the chalkboard and become the class secretary."

$\overline{A}$ $\overline{B}$ $\overline{C}$ $\overline{D}$ 10. Louis is working on a project which involves the hatching of baby chicks. He has decided that when he finishes the project he will try to hatch brine shrimp.

Alternative Approaches to Elementary Science Education

Objective 2 - Post-test

In each statement below, underline your choice of the words in parentheses and then state two reasons for each of your choices in the spaces provided:

A. I believe the (teacher, pupil) should have primary responsibility for stating or selecting educational ends or instructional objectives in science because:

1 ______________________________

____

2 ______________________________

____

B. I believe the (teacher, pupil) should have primary responsibility for selecting or planning educational means or learning activities in science because:

1 ______________________________

____

2 ______________________________

____

C. I believe the (teacher, pupil) should pace most learning activities in science because:

1 ______________________________

____

2 ______________________________

____

D. I believe the teacher should provide pupils with assistance and guidance (individually, in small groups, in one large group) most of the time because:

1____

____

2____

____

Individualizing Instruction

This exercise was written primarily to enable the reader to:

1. Given statements concerning alternative approaches to science education, indicate the nature and extent of individualization by stating:
    - A. Whether or not the ends or objectives are likely being individualized.
    - B. Whether or not the means or learning activities are likely being individualized.
    - C. Whether or not it is likely individualization has been provided by enabling students to pace their own learning activities.

Traditionally, it was assumed that teaching science was largely a matter of planning a "lesson" and "presenting" it to the whole class. Individualization of instruction was talked about--usually in very general terms--but little was done about it. Since reading played a major role in many science programs, individualization was sometimes associated with students' reading ability. Slow readers were not expected to read all of the material, or to answer all of the questions on the dittoed worksheet or the chalk-board. A good reader might have been assigned to write and present a report, while the poor reader might have been asked to build something.

A number of new science programs have been developed in the last decade and the approach to be used in some of them differs little from the traditional approach. The major difference between some of the new programs[1,2] and traditional textbook-centered programs is in the use of large amounts of materials and equipment and emphasis upon student activities rather than heavy dependence upon reading. In other programs[3,4] more concern for individualization has been shown.

Why individualize instruction? A good answer to this question was furnished by Burns who stated:

> The basis for believing that I-I (individualized instruction) is educationally desirable resides in the nature of man. No two living organisms are alike. If this statement is true, and all

evidence appears to support it, then basically we are led to the assumptions that:

1. No two learners achieve at the same rate.
2. No two learners achieve using the same study techniques.
3. No two learners solve problems in exactly the same way.
4. No two learners possess the same repertoire of behaviors.
5. No two learners possess the same pattern of interests.
6. No two learners are motivated to achieve to the same degree.
7. No two learners are motivated to achieve the same goals.
8. No two learners are ready to learn at the same time.
9. No two learners have exactly the same capacity to learn.[5]

When is instruction being individualized? In determining whether or not instruction is being individualized, we must first define the term individualized instruction. We must include in our definition a concern for objectives, learning activities, and pacing, or some combination of these. We should probably also consider such things as whether the appropriateness of objectives and learning activities is to be determined by the teacher or by the pupils, and we should consider the needs of students. Once we have decided how we will include these in our definition, we can then tell whether or not instruction is being individualized--according to our definition!

When we speak of "meeting the needs" of pupils, are we more concerned with needs as they are perceived by the teacher or as they might be expressed through pupils' interests? If a teacher wants all of his pupils to be able to explain the relationships that exist among these structures: cell, tissue, organ, system, and organism--and pupils can't explain the relationships, does a "need" exist? In the eyes of the teacher, yes. If the pupils are quite disinterested in learning to describe the relationships, does a "need" exist? Evidently not--or at least not in the eyes of the pupils.

Some persons indicate that when all pupils are not required to meet the same objectives, instruction is being individualized. The fact that objectives are different for some pupils does not make the objectives appropriate. And, when pupils are pacing their own learning activities and either the objectives or the learning activities, or both, are inappropriate for the pupils, it would be difficult to argue that instruction is being individualized.

Ways to Individualize Instruction

How does one go about individualizing instruction? It isn't easy. It is extremely difficult and time consuming and requires much more on the part of the teacher than can be included in an exercise such as this. In this exercise we are primarily concerned with the major components of the educational process that can be modified so they better fit the needs, abilities, learning styles, and interests of pupils. The major components which can be fitted to pupils are objectives, learning activities, and the pacing of activities.

Objectives can be fitted to individual pupils in three basic ways:

1. Pupils are permitted to plan their own program or to "formulate" their own objectives. (Objectives are determined through choice of activities and are not likely to be stated.)

2. The teacher specifies objectives and requires each pupil to meet only those which he (the teacher) feels will meet pupils' particular needs. (For example, out of twelve objectives in a unit or sequence, one pupil might be required to meet objectives 1, 3, 4, 7, and 10, while a second pupil might meet 1, 2, 4, 5, and 6, while a third pupil might meet all twelve objectives.)

3. The teacher makes a number of prespecified objectives available and pupils are permitted to select from the alternatives.

Means or learning activities can also be fitted to individual pupil needs in different ways:

1. Pupils can be permitted to engage in those activities in which they are most interested (assuming a large variety of materials are available which permit such a procedure).

2. For each objective prescribed by the teacher, two or more alternative learning activities can be made available from which pupils choose the activity that best fits their interest and learning style.

3. For some objectives, pupils may devise their own learning activities.

The pacing of activities can be varied to meet individual needs. This can be accomplished in two ways:

1. Pupils can be permitted to work as fast or as slowly as they wish (assuming independent learning materials are available).
2. The teacher can set a deadline or time at which a certain task, or tasks, must be completed and permit pupils to work at their own pace as long as they are completed by the deadline. (This may be necessary if there are procrastinators in the room.)

Assuming the objectives and learning activities are *appropriate* for pupils, the least extent of individualization occurs when the *same* objectives are prescribed for *all* pupils and *all* pupils must meet the objectives by engaging in the *same* learning activities but are permitted to pace their own activities; that is, to work as rapidly or as slowly as their interest and ability permit.

A greater degree of individualization is possible when *all* students are required to meet the *same* objectives but are permitted to select or develop *different* learning activities and to pace their own activities.

The greatest degree of individualization occurs when students are permitted to select or "formulate" their own objectives and learning activities and to pace their own activities. (We are assuming that what they select or "formulate" is *appropriate*.)

These three approaches to individualization may be summarized thusly:

Same for All Pupils	Different for Most Pupils
1. Objectives and learning activities	Pacing
2. Objectives	Learning activities and pacing
3. Nothing	Objectives, learning activities, and pacing

Which Approach is Best?

Since there are different ways to individualize instruction, teachers may find it difficult to decide which approach to use. Probably the major considerations in deciding upon an approach should be the teachers' philosophical viewpoint concerning:

1. The amount of *freedom* pupils should have in deciding *what*, *how*, and *when* they learn.
2. The amount of *responsibility* pupils should assume in initiating and directing their own learning.
3. Whether the *appropriateness* of objectives and learning activities is to be determined by teacher judgment, pupil interest, or diagnostic testing.
4. The degree of *precision* desired in the teaching-learning-evaluation process.

Unless these four points are given some thought, and decisions regarding each are made prior to attempts to individualize instruction, the results may be somewhat disappointing.

You should be in the process of deciding whether you prefer traditional teacher-centered, large-group instruction or some form(s) of individualized instruction. Whichever approach you choose, it is something you will *work toward*. Over a long period of time you will develop the skills and acquire the materials necessary to implement your favored approach, or approaches, in a manner that is satisfying to you. For our purposes now, we are concerned with whether or not you are able to determine the extent or nature of individualization in various situations. If you are able to do this, you will have some idea as to the type of program you hope to develop and will be able to select and develop appropriate curriculum materials.

Practice

Below are statements concerning science programs and the teaching of science, and statements from materials describing new approaches to education being used in various schools across the nation. Construct a response sheet by numbering your paper from

1-10, and after each number place three short lines. Place an A above the first column of lines, a B above the second column, and a C above the third column. Your response sheet should look like this:

A B C
1______ ______ ______

2______ ______ ______

3 etc. ....

Read each statement below and:

A. Place an x on the first line after each number if there is good reason for believing the ends or objectives are being fitted to individual pupil needs either through student selection or teacher prescription.

B. Place an x on the second line after each number if there is good reason for believing the means or learning activities are being fitted to individual pupil needs either through student selection or teacher prescription.

C. Place an x on the third line after each number if there is good reason for believing students are permitted to pace their own learning activities.

1. The major emphasis of the ______ project is the development of effective communication skills through independent study activities and the evolvement of the library into a learning center to meet these needs.

2. The student signs a contract for released time from class to pursue, through self-direction, the course objectives. He is free to meet with the teacher as often as he feels is necessary to fill course objectives.

3. Using the results of evaluation by individual teachers and written tests, a student's individual needs can be determined and a program of learning mapped out.

4. When in the classroom, the children go to the box, pick out the concept they wish to work on that day, read the information, and attempt to solve the problems.

5. The teachers determine when a student has mastered the skills and concepts, and the student then advances to the next group (of concepts and skills).

6. Each student selects his objectives . . .; five objectives are grouped together in a module. Each objective requires two to three hours to achieve. A student might complete as few as 12 or as many as 24 modules in a year . . .

7. Students enjoy planning their own programs for learning. They remark that it makes them feel more grown-up and that school is more fun now.

8. Individualizing instruction requires a wider variety of materials than the traditional educational setting.

9. The ultimate goal is for a self-directed student to assume responsibility for making the following decisions:
   How long to work on an activity,
   When to work on an activity,
   When an activity has been mastered,
   Which activity to do first,
   What materials to use,
   Where to work, and
   With whom to work.

10. The first section of this unit deals with the formation of the earth, as well as theories on how it was formed and the reasons for some of the beliefs. The second section deals with the rocks, minerals, and crystals found in the earth. As you and the class proceed in your study of this unit, there will be many new terms, words, and expressions which are peculiar to science and, more particularly, to geology.

Correct responses and discussion of above items:

1. C should have been checked. All we know for sure is that pupils are working independently. When students work independently, they usually pace their own activities. They

may be meeting the same objectives and engaging in the same activities, but not at the same time.

2. C should have been checked, possibly B also. "Self-direction" indicates the student is working independently, therefore, pacing his own activities. However, we don't know whether the activities are prescribed by the teacher and are the same for all pupils, or whether they were selected or developed by pupils.

3. ABC should have been checked. If students' programs are based on pretesting, then each student should have a program tailored to his needs or deficiencies as they are perceived by the teacher. When this is the case, objectives will be varied for pupils. It may be though that in the event a number of pupils have to master the same objective, all of these pupils will engage in the same activity; therefore, we are less sure about checking B than we are about A and C.

4. Evidently, students can work on any concept they choose; therefore, objectives are being individualized and A should have been checked. It is difficult to tell whether two pupils who choose the same card--at different times--would engage in the same activity. If the procedures to use--the activities--are given on the card, B should not have been checked because all students who choose a certain card would engage in the same activity. If students were to devise a procedure for solving the problems, B should be checked. Since students are free to select any card, and since they are working on different cards, they must be pacing their own activities, therefore, C should be checked.

5. C should have been checked. Since the teachers determine when a student has mastered the skills, students must be working independently. Therefore, they are quite likely pacing their own activities.

6. AC should have been checked. Students are not likely to select the same objectives; therefore, ends are individualized. If some students are completing only 12 modules a year and some 24, they obviously work at different rates. If students work at different rates, they pace their own activities.

7. ABC should have been checked. A program consists largely of ends and means, or objectives and related activities. Since students are planning their own programs, they surely plan different programs; therefore, both ends and means are individualized. If both ends and means are individualized, it automatically follows that students pace their activities.

8. Nothing should have been checked. We are left wondering as to the extent and nature of the individualization.

9. B and C should have been checked. The selection of objectives is not listed as one of the responsibilities the child is expected to assume; therefore, A should not have been checked. Since the self-directed students decide many things relative to their activities, such as what materials to use, means are being individualized. Considering the decisions pupils make, it is quite obvious they pace their own activities.

10. Nothing should have been checked. This appears to be teacher-centered, teacher-controlled, large-group instruction with no provision for any type of individualization.

When a teacher remarks, "I am individualizing my science program," what is the teacher telling us? What if he tells us he is permitting his pupils to pace their own learning activities, or that his pupils are free to select their own learning activities, or that his pupils are free to select from a group of teacher-stated-instructional objectives? We now have a good idea as to the nature of his program. Only when we know which components of the educational process have been fitted to pupils' needs, abilities, interests, and learning style and how these components have been fitted to pupils are we able to understand what is meant by "individualizing instruction."

References and Other Sources of Related Information:

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2. Science Curriculum Improvement Study, University of California, Berkeley, Calif. (Published by Rand McNally & Company, Chicago).

3. Elementary Science Study, Newton, Mass. (Published by McGraw-Hill, Manchester, Mo.).

4. Individualized Science, Imperial International Learning Corporation, Kankakee, Illinois.

5. Richard Burns, "Methods for Individualizing Instruction," *Educational Technology*, XI (June, 1971), 55-56.

6. Jack V. Edling, *Individualized Instruction* (A Manual for Administrators, Six Film-strip-Tape Programs, and Forty-six Accompanying Brochures), Dept. of Audiovisual Instruction, National Education Association, 1201 Sixteenth St., NW., Washington, D. C.

7. Helen Davis Dell, *Individualizing Instruction: Materials and Classroom Procedures*, (Chicago: Science Research Associates, Inc.), 1972.

8. Helen Davis Dell, Philip G. Kapfer, and Glen F. Ovard, *Preparing and Using Individualized Learning Packages for Ungraded, Continuous Progress Education*, (Englewood Cliffs, N. J.: Educational Technology Publications), 1971.

9. Sidney J. Drumheller, *Handbook of Curriculum Design for Individualizing Instruction*, (Englewood Cliffs, N. J.: Educational Technology Publications), 1971.

Individualizing Instruction

Pretest

Indicate the nature and extent of individualization in the programs described or referred to in the statements below by:

A. Placing an x above the A if there is good reason for believing the ends or objectives are being fitted to individual pupil's needs, interests, and abilities either through student selection or teacher prescriptions.
B. Placing an x above the B if there is good reason for believing the means or learning activities are being fitted to individual pupil's learning styles either through student selection or teacher prescriptions.
C. Placing an x above the C if there is good reason for believing students are permitted to pace their own learning activities.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 1. The primary objective of the program is to develop individual capacities of each learner through self-selected and self-directed activities. . . through the provision of guidance, suitable environment, equipment and materials.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 2. Students are not pressured to complete their research in any specified amount of time but are encouraged to use as much time as they need in order to do a thorough job.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 3. . . . it is helpful to cluster the children close to the teacher so they can follow the demonstrations and focus their attention more strongly . . .

$\overline{A}$ $\overline{B}$ $\overline{C}$ 4. Teachers use different types of tests at frequent intervals to determine whether the pupils have the required proficiency.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 5. Students . . . are given the opportunity to progress at their own rate. They utilize their own style of learning, either individual research or extensive teacher aid.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 6. Once a student has selected his objective, he has a choice of three suggested learning activities. Pupils always have as a fourth choice any activity they might devise.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 7. Units are divided into daily lessons. All the lessons are designed to bring students into contact with the natural world through easily performed classroom activities, enabling them to build specific scientific concepts.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 8. The child is learning science as he reads the textbook and enters into the experiences outlined for him. . .

$\overline{A}$ $\overline{B}$ $\overline{C}$ 9. A unique feature . . . is that each student has individual, written prescriptions to meet his needs and interests. The prescription is a detailed individual plan which lists the material that the pupil is to study.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 10. The . . . program is designed to be used as the initial classroom science experience for young children. The program is structured for use with the basic, average, and advanced child.

Individualizing Instruction

Post-test

Indicate the nature and extent of individualization reflected in the statements below by:

A. Placing an x above the A if there is good reason for believing the ends or objectives are being fitted to individual pupil's needs, interests, and abilities either through student selection or teacher prescriptions.

B. Placing an x above the B if there is good reason for believing the means or learning activities are being fitted to individual pupil's learning styles either through student selection or teacher prescriptions.

C. Placing an x above the C if there is good reason for believing students are permitted to pace their own learning activities.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 1. When a student proceeds on his own with learning materials he has selected, . . . he is functioning in the "individualized mode."

$\overline{A}$ $\overline{B}$ $\overline{C}$ 2. Given precise objectives and alternate learning packages, the learner can be given the responsibility to select tasks appropriate to his needs.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 3. Print on the chalkboard HEARING TEST. When the room is quiet, ask: "What do you hear?" Make a list of the sounds the children name.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 4. Each of the lessons included in this book is a complete teaching lesson. In using the lessons, particularly in the lower grades, the teacher should read the discussion and the pupil investigation sections to the class.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 5. . . . each student has individual, written prescriptions to meet his needs and interests. These prescriptions are developed after evaluation of the pupil's record. The prescription is a detailed individual plan which lends direction and assigns materials the pupil is to use.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 6. Some students will finish sections of this program before other students. As a student completes a section, the next section should be readily available to him.

$\overline{A}$ $\overline{B}$ $\overline{C}$ 7. The atmosphere in the . . . classroom is relaxed and yet controlled. The teacher has two functions: to be an observer who listens to the children and notices how well they are progressing in their investigations, and to be a guide who leads the children to see the relationship of their findings to the key concepts of the course.

$\overline{\text{A}}$ $\overline{\text{B}}$ $\overline{\text{C}}$ 8. . . . students accept the fact that learning is their individual responsibility. The key to individualization is the Multi-Mode approach, in which there are a variety of methods available to children to enable them to acquire a particular instructional goal.

$\overline{\text{A}}$ $\overline{\text{B}}$ $\overline{\text{C}}$ 9. To provide opportunities for an entire class to experience the processes of science, the equipment and materials are supplied in multiples of six, except in the case of certain types of equipment for which one item is adequate for the experience of all the children. A class of 30 pupils, for example, may be divided into six groups of five pupils, with each group performing the same investigation.

$\overline{\text{A}}$ $\overline{\text{B}}$ $\overline{\text{C}}$ 10. The development of contracts with specific objectives is the primary technique used. There may be four or five different sources a student may choose in each contract. Thus, the learner is given a choice within the terms of the objective. He is making decisions about and assuming responsibility for his own learning.

Sources of Objectives and Emphases in Science Education

This exercise was written primarily to enable the reader to:

1. Name four primary sources of science education objectives and name the emphasis related to each of the three major sources.

2. Given statements from various science program materials, state the probable source of the majority of the objectives of the program from which each of the quotes was taken, and state the major emphasis of the program from which each quote was taken.

3. State which emphasis in science you believe to be most appropriate for the grade(s) which you teach (or hope to teach). List three reasons why you selected that emphasis, and list two reasons why you did not select each of the other two major emphases.

All persons expect the school to bring about certain changes in pupils. There is considerable agreement that teachers should promote general kinds of changes such as these: intellectual, social, emotional, physical, attitudinal, etc. There is much disagreement concerning the more specific types of changes we should promote. Therefore, teachers must choose from among many types of changes those which they will work toward promoting in science.

If you were asked to list three specific instructional objectives, or to describe three ways in which pupils should grow in science, how would you respond? If you do not know the nature of the things that might be listed, where would you go in order to locate some things you might list or describe? Your first source would probably be a book of some type. Where do you think the authors of books go, or what do you think they examine or consult when listing the ways in which they think pupils should grow or change in science?

Sources of Objectives

Three decades ago, Tyler[1] indicated that there are three possible sources of education objectives or things to analyze in order to identify goals to work toward: (1) society, (2) subject matter, and (3) children. A number of noted authorities[2] in the area of curriculum development contributed to a symposium on sources of the curriculum and one of the concerns of the symposium was sources of objectives. There was general agreement among the contributors with the three sources listed by Tyler. However, a fourth source of objectives for science education has evolved. That source is the ways scientists think and work.[3,4]

Below are four example goals or objectives which were derived from an analysis of each of the four sources of objectives for science education:

1. Derived from an analysis of the needs of society:
   "Understand the causes and effects of pollution."
2. Derived from an analysis of subject matter:
   "Describe the conditions that are necessary for atoms to form chemical bonds."
3. Derived from an analysis of the needs of children:
   "Develop a positive attitude toward self."
4. Derived from an analysis of the ways scientists think and work:
   "Identify the variables that are manipulated in an investigation."

Society as a Source of Objectives

Programs based on objectives which have been stated with a preoccupation of the needs of society lead to studies involving the nature of persistent and recurring social problems, social and democratic processes, group dynamics, valuing and normative behavior, organismic and topological concepts of learning and status and role determining processes.[5]

An elementary science program with objectives derived largely from an analysis of the needs of society is not available at this time. However, Carin[6] made a plea for such a program. He indicated that:

> Children's exposure to the following events and issues stir excitement, fear, questions, and anger around which the society-oriented science program can be built:
>
> Pollution and waste of natural resources
> Space missions
> Heart transplants
> Poverty
> War
> Disease
> Starvation
> Adequate testing of the "Pill," cyclamates, etc.
> Racial conflicts
> Overpopulation
> Drugs, alcohol, tobacco, and chemical control
>   of man's mind
> Use of insecticides
> Death

Subject Matter as a Source of Objectives

Programs composed of objectives largely derived from an analysis of subject matter involve problems of generalizing, the cognitive processes, the logical structures of subject matter, transfer of training, readiness, repetition, motivation, retention, and the capacity of the individual to learn.[7]

Below is a paragraph from a trial edition of the Science Curriculum Improvement Study program unit Life Cycles. Note the obvious concern for subject matter in the first sentence and the nature of the subject matter emphasized in the unit:

> The overall concept that has guided us in building the program is that of the ecosystem. Thinking about a forest may help you understand this concept. What is a forest? It is trees, of course, but for any given forest, it is not just one kind of tree. Nor is a forest just trees alone. Trees are only the most conspicuous

> members of a forest. Living in the shade of the trees may be many kinds of shrubs, vines, herbs, ferns, mosses, and toadstools. In addition, the forest swarms with insects, birds, mammals, reptiles, and amphibians. The number of all the different kinds of plants and animals that live together are tied to each other by mutual dependencies that involve food and living conditions. This multitude of life does not merely live in the forest--it is the forest. And each kind of organism plays a role in an intricate pattern of relationships. Should any part of that pattern be destroyed, the entire pattern would be affected and eventually the forest itself might be destroyed.[8]

Concern for pupils learning and retaining subject matter is indicated in the objectives in the Life Cycle unit. Some of the objectives are:

1. To recognize fruits as the original source of seeds.
2. To recognize variation in the shape and size among seeds.
3. To identify the parts of a germinating seed.
4. To recognize that plants are alive.
5. To recognize vegative reproduction as a supplement to sexual reproduction in some plants.
6. To identify the major stages of a developing frog.
7. To relate the concept generation to that of life cycle.
8. To infer the biotic potential of organisms.

(In a revised edition of the unit Life Cycles, the authors eliminated some of the objectives that had been derived from an analysis of subject matter and included some objectives that were derived from another source--the ways scientists think and work.)

The objectives of most of today's science programs were derived from an analysis of subject matter. Most programs include units on such things as: plants, animals, earth, the solar system, the universe, matter and energy, the oceans, heat, light, electricity, rocks and minerals, air and weather, sound, space travel, and simple machines.

In programs which are largely subject-matter centered, statements such as the following are common:

Children observe different forms of matter, different ways of moving matter by using simple machines, and different kinds of energy. From their experiences and observations, children develop these concepts.

Matter exists in different forms.
Simple machines are used to help us do work (move matter.)
Heat and light are forms of energy.[9]

Descriptive brochures, promotional materials, and teachers' guides of subject-matter centered programs contain reference to science facts, concepts, principles, and generalizations, the "big ideas" in science, content, the products of science, the major conceptual schemes of science, and similar terms.

Tests designed to evaluate pupils' understanding of science subject matter include such things as the following:

1. (True-False) Organisms are made up of cells.
2. (True-False) Air is a mixture of gases, liquids, and solids.
3. (True-False) A device for measuring wind speed is a radiosonde.
4. (Completion) A _________ is a mature ovule containing an embryo and one or more cotyledons.
5. (Completion) __________ is the process in which green plants produce food materials.
6. (Multiple Choice) Which place is a habitat of a shark?
    a. salt water
    b. air
    c. fresh water

If you decide to promote subject-matter learnings such as those above, your major aim will be to teach children about science--about those things that scientists have learned about our world.

How would you motivate pupils in order to get them to learn subject matter such as that above? How long do pupils retain such information? These are only two of the concerns pointed out previously that teachers have when their objectives have been derived from an analysis of subject matter.

Children as a Source of Objectives

Programs in which the objectives have been largely derived from an analysis of the needs of children lead to considerations of the self-perceptive process, the identification of persistent and recurring concerns of the individual, questions of creativity, phenomenological fields, biological growth processes, and what constitutes maturity and social, emotional, physical, and intellectual development.[10]

There is not available at this time a commercial science program with objectives which have been largely derived from an analysis of the needs of children. However, the Elementary Science Study program materials seem to indicate developers of the materials were more concerned with children than with society, subject matter, or the way scientists think and work. For example, the following quote from the Light and Shadows unit reflects more of a concern for children as individuals than for subject matter:

> In exploring Light and Shadows, try to respect the individual paces children set for themselves and the depth to which each is willing to work. Some children, for example, will readily accept your suggestions . . . a few may reject the idea entirely. Some children may figure out that changes in a shadow's position--morning, midday, and afternoon--provide a kind of clock; others may set themselves the task of finding out why the shadow is directly in front of the building one time, skewed off in another direction later; some may barely see the relation between the position of the shadow and the position of the sun. Try to content yourself with the inevitable: a crumb satisfies some children; others seek the full fare.[11]

Scientists as a Source of Objectives

Programs containing objectives that were largely derived from an analysis of the ways scientists think and work lead to the same considerations as programs with subject-matter centered objectives. Among the concerns are: the logical structure of the skills or science processes to be learned (rather than subject matter), readiness, motivation, transfer of training, retention, and the capacity of each individual to learn the specified skills or processes.

Below is a statement from the Science-A Process Approach elementary school science program. The objectives in the SAPA program were supposedly largely derived from an analysis of the ways scientists think and work (See references 3 and 4). Note the obvious concern for pupils learning the skills or processes which scientists are believed to engage in.

> In this PROCESS APPROACH the complex set of skills a scientist uses in conducting a scientific investigation are broken down into a number of processes which must be mastered if the learner is to develop a sound knowledge of science and its methods.[12]

Some objectives from the SAPA program which indicate the authors of the program were more concerned with the investigative aspect of science than with science subject matter are:

1. Identify the variables that are manipulated in an experiment . . .
2. Distinguish between statements that are hypotheses and those that are not.
3. Construct an operational definition of an object in descriptive terms.
4. Construct an inference based on a hypothesis about conductors and nonconductors.

Programs that are process centered, or which were developed primarily for the purpose of teaching children to become skilled in the processes of science, contain terms such as: process, skills, investigation, intellectual skills, inquiry, problem solving, techniques of scientists, and other terms which are the names of the skills or processes of science. Some processes are: observing, experimenting, formulating hypotheses, inferring, controlling variables, classifying, predicting, recording data, and measurement.

Evaluation of process-centered objectives usually calls for children to demonstrate some competency with a skill through the use of science materials rather than being evaluated with a pencil-paper test composed of true-false, completion, multiple-choice, and matching test items. For example, a "test item" in the Science-A Process Approach program calls for children to construct a complete electric circuit with a flashlight cell, a lamp, and two wires. If you decide to promote process-centered learnings, your major goal will be to have children engage in science somewhat like a scientist does rather than to have them learn science subject matter.

Sometimes the source of the majority of a program's objectives is not as obvious as that above. The authors of one science program stated that "Certain science education goals have guided the authors in their development of . . ." They went on to list the following goals:

1. To develop a better understanding of the natural, physical world.
2. To gain some understanding of the methods used in the sciences.
3. To learn more about the needs of all living things, including the needs of the human body.
4. To take part in the exciting adventures that lie ahead in science and technology.
5. To prepare for effective citizenship.

Goals one and three above relate to the subject matter of science, and goal two relates to the way scientists think and work. Goal five is related to society, and goal four seems also to be related to society. It is quite obvious from the above that considerations involving children evidently influenced the authors very little in the development of the program. From the above goals it is difficult to state with any degree of certainty the source of the majority of the program objectives. However, later clues in the manual from which the five goals were taken does enable us to state the probable source of most of the program objectives. It was stated by the authors that:

> In this first unit . . . you and your class will study why the moon looks the way it does, the reasons for its constantly changing apparent shape, and the nature of its surface features.

Statements such as the above indicate the program is subject-matter centered, or that the majority of the objectives were likely derived from an analysis of science subject matter.

A great deal of information will usually be available from which one can determine the source, or sources of a program's objectives. Space limitations prevent the use of a large amount of information here; therefore, below are some short quotes taken from various science program materials. On the basis of the information given, which of the three major sources of objectives (subject matter, the ways scientists think and work, and children) do you believe the objectives in the programs from which the quotes were taken were derived from? (Number your paper from 1-7 and name the source reflected in each quote.)

1. The concept of the ecosystem serves as a guide for the selection of topics to be introduced and also provides clues to the materials that can be used and the sequence in which the topics should be presented.

2. The . . . has designed its units so that the concepts used become increasingly complex as the children mature. The overall program is structured around the fundamental concepts of physical and biological sciences, and the concepts are organized into ascending levels of abstraction. Complex concepts such as energy and natural selection are built on earlier and simpler ones such as systems and organisms.

3. . . . experiences in teaching . . . (the unit) revealed that children could find out a surprising amount about mealworms by making careful observations and performing simple experiments. Further, through such observation and experimentation, the children developed significant sophistication about how to approach a problem, about interpreting and evaluating data, and, in general, about scientific inquiry.

4. . . . is not a textbook course . . . it is not "content" (subject-matter) oriented. Even though a wide variety of science areas are explored, content is the vehicle or means--not the end. Because the program is process oriented, children can learn with a minimum of reading skills, which makes the program workable for pre-readers and poor readers. The emphasis is always on active participation by each child as scientific investigations are carried on.

5. What is inquiry and how can it be stressed? Inquiry is a way of directing questions and finding their answers by applying the techniques of science. Some techniques used in science are observing objects and events, asking questions about them, and doing things to find answers and test them--all important aspects of process science. Inquiry encompasses problem solving through the discovery approach. Other techniques used in the discovery approach--besides observing and questioning--include measuring, guessing, inferring, concluding, and testing. All these techniques are involved in the process-oriented method of problem solving.

6. In . . . Level One, pupils develop concepts relating to the great variety and diversity of animals and plants. In . . . Level Two, the pupils take a closer look at animals and plants, developing a concept of the activities and habitats of living things. In . . . Level Three, a still closer look is taken at animals and plants, leading to an understanding of the nature of communities and the nature of adaptations.

7. The materials can be kept in a specific place in the classroom, and the children can come to them when they have time available before, during, or after school. Depending on their interest, they will want to spend anywhere from a few minutes to hours at a time with the tangrams. Many will probably want to take them home. In any case, the children should proceed at their own pace after you introduce the tangrams and should need little supervision thereafter.

Correct responses:

1. The term "ecosystem" and the statement "sequence in which the topics should be presented" should have made you think of science subject matter as the probable source of the majority of the objectives of the program from which the statement was taken.

   It is customary today to think in terms of "presenting subject matter" to a class or a group of children.

2. The major concern of the authors of the program from which this quote was taken appears to have been science subject matter. The terms "concepts," "physical and biological sciences," "energy," "natural selection," "systems," and "organisms" are all terms that most persons associate with science subject matter.

3. Terms such as "observations," "experiments," "problem," "interpreting and evaluating data," and "scientific inquiry" indicate the most probable source of the majority of the objectives of the program from which the quote was taken was the ways scientists think and work.

4. We are told quite clearly the program from which this quote was taken is not "content" or subject-matter oriented. The terms "process" (about which you will learn more later), and "scientific investigations" indicate the program objectives were likely derived from an analysis of the ways scientists think and work.

5. "Inquiry," "techniques of science," "process," "problem solving," "measuring," "inferring," and similar terms lead us to think the majority of the program objectives were derived from an analysis of the ways scientists think and work.

6. This quote leads us to think the majority of the objectives of the program from which the quote was taken were derived from an analysis of subject matter. However, this quote and quote five above were taken from the same program. To be sure of the source of the majority of the objectives, we should examine the suggested tests and learn the source of what is being evaluated. Many times, tests are better indicators than other types of statements as to the source of the majority of a program's objectives.

7. Evidently, children are free to work with tangrams or not, depending upon their interest. Since there is little or no concern voiced for subject matter, or for the ways scientists think and work, or the skills scientists use, and since the children are free as to when and how long they work with the materials, the authors of the program from which the statement was taken appear to have been primarily concerned with the needs of children. However, this quote was taken from the same program as quote three--but not from the same unit. It appears that, in this program at least, some units have objectives reflecting one source of objectives while other units in the same program reflect other sources.

Based upon your present knowledge of the three major sources of objectives for science education (subject matter, children, and the way scientists think and work), which source seems to be the most appropriate source of objectives for the children which you teach, or hope to teach? What are your reasons for choosing this source? What are your reasons for rejecting the other two sources?

Identifying the Source of A Program's Objectives

Pertinent sections of teachers' manuals and other program literature usually indicate or provide clues to the major source of the majority of the objectives of a program. Below is a paragraph from a teacher's manual. Which of the three major sources of objectives (subject matter, the ways scientists think and work, and children) do you think the majority of the objectives of the program from which the paragraph was selected were derived from:

> Science concepts are interrelated. Change, for instance, is introduced in Unit One in relation to the study of the earth and its structure. In later units, change is reintroduced and reused in relation to physical and chemical change, matter and energy, growth of plants, the development of the human body, the development of living things over the ages, and in a study of other bodies in the solar system. The concepts of matter, energy, interdependence, etc., are similarly introduced, reintroduced, and reused in more than a single unit.

The emphasis upon concepts and the frequent reference to science subject matter (the earth and its structure, physical change, matter and energy, growth of plants, etc.) indicate the authors of the program from which the above quote was taken probably derived most of the program objectives from an analysis of the subject matter of science.

Below is a paragraph from a program with objectives derived from an analysis of the ways scientists think and work:

> The . . . program is process centered. This meaning of process centers upon the idea that what is taught to children should resemble what scientists do--the "processes" that they carry out in their own scientific activities. Scientists do observe, and classify, and measure, and infer, and make hypotheses, and perform experiments. If scientists have learned to gain information in these ways, surely the elementary forms of what they do can be learned in the early grades.

Emphases in Science

Teachers seldom teach only that which they intend to teach. In teaching a unit on insects, in addition to the major unit objectives, a teacher is likely to teach some of his pupils to like science, a few to dislike science, some to fear certain insects, some to want to know more about certain insects, etc. However, in teaching, some things are *emphasized* (these are usually described in the unit objectives) and some things are considered only in an incidental manner. Many times the teacher is unaware of many of the incidental learnings that occur. It may be that the incidental learnings are sometimes as important, and sometimes more important, than those things that are emphasized.

In teaching science, you will either develop your own instructional materials (resource units, teaching units, lesson plans, and material for individualizing instruction), or you will be supplied with a set of commercially prepared materials--which you may or may not have had a hand in selecting. The chances are great that, whichever type of materials you use, you will emphasize either the *products of science* (subject matter), the *processes of science* (the skills scientists use), or *the needs of your pupils* as expressed primarily through their preferences or their needs as viewed by you.

Products of Science

Programs with objectives which were largely derived from an analysis of science subject matter are usually called subject-matter or content-centered programs. Or, one might say that in such programs the major conceptual schemes of science, i.e., the major generalizations or the "big ideas" of science are emphasized. Regardless of the terminology used, the *main emphasis* in a school science program in which such materials are used is the learning of subject matter, content, or the *products* of science.

Among the programs now being developed, or currently available, whose objectives are said to be largely product-centered are: the Science Curriculum Improvement Study program (SCIS);[13] Conceptually Oriented Program in Elementary School Science (COPES);[14] and a number of traditional textbook series. Some objectives from the SCIS materials which are representative of the kinds of objectives in programs in which the major emphasis is upon the products of science are:

1. To identify the major stages in the life cycle of a frog.
2. To describe the parts of a germinating seed.
3. To interpret dissolving and chemical change as evidence of interaction.
4. To distinguish between the solids and solutions which are electrical conductors and those which are not.
5. To describe and identify the position of objects relative to reference objects in the children's immediate environment.

In programs in which objectives such as those above are emphasized, many things might take place and many things might be learned. But the main intent of school personnel who select a program with objectives of this type is that their students acquire a certain amount of science information--to learn about the world in which they live--to understand the "big ideas" or major conceptual schemes of science--or, to have a good understanding of certain products of science.

Processes of Science

Instead of placing emphasis upon children learning the products of science, teachers may choose a program in which the processes of science are to be emphasized. Programs with objectives which were derived primarily from an analysis of the ways scientists think and work are used when teachers wish to emphasize the processes of science.

The processes of science, i.e., the intellectual skills scientists use in their work, have been stated in different ways by different writers. Gega lists five processes or skills:

1. Stating problems and making operational definitions.
2. Suggesting and appraising hypotheses.
3. Developing and selecting valid procedures.
4. Interpreting data and making inferences.
5. Reasoning quantitatively.[15]

In speaking of process, Carin and Sund mentioned scientific attitudes and scientific inquiry.[16] Investigation, experimentation, *discovery*, and *inquiry* are words commonly associated with process science. Other less "sciency" terms which have a process connotation are: learning by doing, active participation, student involvement, experience-centered, and student-directed. Supposedly, when the program can be described by words such as these, children are, hopefully, engaging in intellectual skills or processes similar to those engaged in by scientists when they investigate.

Probably the best known process-centered elementary science program is Science-A Process Approach.[17] Developers of this program identified thirteen major skills or processes in which scientists engage and developed lessons to be used in teaching elementary children these same skills. The skills or processes emphasized in the SAPA program are:

1. Observing
2. Using space/time relationships
3. Using numbers
4. Measuring
5. Classifying
6. Communicating
7. Predicting
8. Inferring
9. Formulating hypotheses
10. Controlling variables
11. Interpreting data
12. Defining operationally
13. Experimenting

Some instructional objectives from the Science-A Process Approach program which are said to be process centered are:

1. Identify variables that might affect the time a round object takes to roll down an inclined plane. (The process involved is Controlling Variables.)

2. Construct inferences about the geometric shape of a solid object based on observations of its transverse and longitudinal sections. (The process involved is Inferring.)

3. Distinguish between an operational and non-operational definition of an object, a situation, or an event related to simple electrical circuits. (The process involved is Defining Operationally.)

4. Apply a rule for finding the linear speed of a rolling wheel given its angular speed and its circumference or diameter. (The process involved is Using Space/Time Relationships.)

5. Construct a force diagram to illustrate that an unbalanced force is acting on a body that is changing speed. (The process involved is Communicating.)

It is obvious from the above instructional objectives that some products of science are involved in objectives which are said to be process centered. However, in a program in which the processes of science are emphasized, the products of science (subject matter) are treated in an incidental manner. It is desired that children become skilled in the processes of science instead. If children learn to identify variables which affect various happenings, presumably they will be able to identify the variables affecting many changes around them. It is believed by developers of the Science-A Process Approach program that skills or processes such as those above have transferability.

Development of Children's Potentials

The third major emphasis in elementary science is more difficult to identify and to describe than the product and process emphases. The product emphasis is easy to describe because many years have been spent in developing an established rationale and related information and materials. In the last decade much has been written concerning the process approach and a basis for the approach is rapidly becoming established. While much has been written about child development, and an extensive vocabulary has been established, most of what has been written has not been concerned with an analysis of the needs of young children as the primary emphasis in an elementary school science program.

Some persons are quite concerned today that young children receive stimulating experiences which are believed to promote intellectual, emotional, social, language, and physical growth.[18] These persons seem less concerned about children learning subject matter, or the products of science, or learning to think and work like scientists, or becoming skilled in the processes of science. Persons who believe this see science in the elementary school as a vehicle (means) through which rich experiences can be provided children.

A science program composed of experiences designed to promote the development of children's potentials would have objectives derived primarily from an analysis of the needs of children. Therefore, we might say the emphasis in such a program is the *development of children's potentials*, and we might refer to such a science program as an *experiential* program because *the nature of the experiences in which children engage* is considered more important than either the science subject matter children might retain, as when the products of science are emphasized, or the processes in which they might become skilled, as when the processes of science are emphasized.

It is believed by some persons that the first step in developing a science program is the stating of objectives. In actual practice, this is seldom done (as an examination of the *ends* and *means* of many programs indicate). Certainly, it would be an extremely difficult task at the present time to state, with any degree of certainty, a list of objectives concerning the *real* intellectual, emotional, social, language, and physical needs of children which might be met through experiences in science.

Since, in an experiential program, the main concern is the nature of the experience which children have rather than what is retained for possible use long after the experience, there is a tendency for a developer of an experiential program to think in terms of describing experiences rather than in terms of stating instructional objectives. Such a description of experiences might be:

1. Examine algae with a microscope
2. Hatch brine shrimp
3. Go on a field trip to the game preserve
4. "Experiment" with mealworms
5. View the film "Beach and Sea Animals"

Some persons refer to statements such as the above as "expressive objectives," but it is obvious the statements are means oriented--they are descriptions of activities--rather than ends oriented.

Identifying Sources of Objectives and Emphases in Curriculum Materials

Obviously, if one can identify or determine the source of the majority of the objectives in a program, he knows the major emphasis--as is apparent from the following:

Source of Objectives	Major Emphasis	(Considered Incidentally)
Subject matter.......	Products of science.....	Processes of science and needs of children
Ways scientists think and work......	Skills or processes of science.....	Products of science and needs of children
Needs of children....	Developing children's potentials...	Products and processes of science
(Society	____________________________)	

Below are some statements from various sources. Construct a response sheet like the following and on the first line following each number, write the probable source of the majority of the objectives of the program from which the statements were taken, and on the second line write the major emphasis reflected in each statement. (Your response sheet should look like this:)

Major Source of Objectives	Emphasis
1A____________________	1B____________________
2A____________________	2B____________________
3A____________________	3B____________________
4A____________________	4B____________________
5A____________________	5B____________________

1. End of chapter questions:

   How is man carried into space?
   How can a man in space tell that the earth is round?
   How can a man in space see?
   How is a spaceship slowed down?
   How is a spaceship turned?

2. Science concepts developed in the section "Why Do You Need More Food?"

    1. Food provides energy for the body.
    2. The foods that provide energy are called sugars, starches, and fats.
    3. The body stores excess energy foods as fat.
    4. The body cells need protein foods to multiply.

3. ________ has the following goals:

    a. ______ enhance the thinking ability of the child. It provides activities compatible with pre-operational, concrete operational, and formal operational though in the pursuit of investigations of the environment or the solution of problems.
    b. ______ enhances the child's belief that he can interpret and manipulate his own environment--that he is a part of his environment and dependent upon it.
    c. ______ facilitates individual development of interests, attitudes, personality and creativity which enhance the continued development of individuality in the learner.
    d. ______ facilitates the child's tendency to accept the existence of individuals who have ideas and values which are different from his own.

4. Every scientist, from the anthropologist to the zoologist, makes use of certain definable intellectual tools in the investigation of natural phenomena. . . . pupils learn to use the intellectual tools and skills of science; they learn to think and work as scientists think and work.

5. The procedures of science described here in the context of early science education are recognizably the procedures of science at all levels of sophistication. Scientific inquiry is a seamless fabric. The content will change, the demand for precision will vary, the generality of conclusion will be different, . . . but the procedures and attitudes of scientific study remain remarkably the same. . . .

Keep in mind that statements such as those above, when quoted out of context, may be misleading; however, you were asked to respond as if the only information available was that contained in the quotes. Based only on the information provided, the "correct" responses are:

Major Source of Objectives	Emphasis
1A. Subject matter	1B. Products of science
2A. Subject matter	2B. Products of science
3A. Children	3B. Developing children's potentials
4A. Ways scientists think and work	4B. Processes of science
5A. Ways scientists think and work	5B. Processes of science

Can you do the following:

1. Name four primary sources of science objectives?
2. Name the emphasis related to each of the three major sources of objectives? (Society is not considered here as being one of the major sources.)
3. State which emphasis you believe to be most appropriate for the grade(s) which you teach (or hope to teach)?
4. List three reasons why you selected that emphasis?
5. List four reasons why you did not select the other two major emphases--two reasons for rejecting each of the two emphases?

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3. J. Myron Atkin, "'Process' in Science Education," A paper presented at the Sixteenth Annual Convention of the National Science Teachers Association, Washington, D. C., March 29-April 2, 1968.

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5. Virgil E. Herrick, "Sources of Curriculum Development," *What are the Sources of the Curriculum*?, op. cit., p. 62.

6. Arthur A. Carin, "Let's Have Some Humanistic, Society-Oriented Science Teaching!" *Science and Children*, 9 (October, 1971), 29-32.

7. Herrick, op. cit.

8. *Life Cycles*, Teacher's Guide, (Chicago: Rand-McNally Company) 1967, pp. 1-2.

9. Herbert A. Smith, Milo K. Blecha, and Herbert Pless, *Modern Science Level Three*, (River Forest, Ill.: Laidlaw Brothers, Pub.), 1972, pp. T-12.

10. Herrick, op. cit.

11. *Light and Shadows*, Teacher's Guide, (St. Louis, Webster, Division, McGraw-Hill Book Company), 1968, p. 2.

12. *Science-A Process Approach*, *Description of the Program*, *Part A* (New York, Xerox), 1969, p. 3.

13. Science Curriculum Improvement Study, Robert Karplus, Director, University of California, Berkeley, California (Materials published by Rand-McNally Company).

14. Conceptually Oriented Program in Elementary Science, 4 Washington Place, Room 502, New York, N.Y. 10003.

15. Peter C. Gega, *Science in Elementary Education*, 2nd Edition, (New York: John Wiley & Sons, Inc.), 1970, pp. 70-71.

16. Arthur A. Carin and Robert B. Sund, *Teaching Science Through Discovery*, (Columbus, Ohio: Charles E. Merrill Publishing Company), 1970, pp. 6-13.

17. *Science-A Process Approach*, American Association for the Advancement of Science, 1515 Massachusetts Avenue, Washington, D. C. (Materials published by Xerox Corp.)

18. Arthur W. Combs, "New Concepts of Human Potentials: New Challenge for Teachers," *Childhood Education*, 47 (April, 1971), 349-355.

Sources of Objectives and Emphases in Science Education

Objective 1 - Pretest

In the spaces below, name the four primary sources of science education objectives, and name the emphasis related to each of the three major sources.

Source of Objectives	Related Emphasis
1A______________	1B______________
2A______________	2B______________
3A______________	3B______________
4A______________	

Objective 2 - Pretest - (Response sheet - test is attached)

Source of Objectives	Related Emphasis
1A______________	1B______________
2A______________	2B______________
3A______________	3B______________
4A______________	4B______________
5A______________	5B______________
6A______________	6B______________
7A______________	7B______________
8A______________	8B______________
9A______________	9B______________
10A______________	10B______________

Sources of Objectives and Emphases in Science

Objective 2 - Pretest

Below are quotes from various elementary science program materials. Such quotes are sometimes misleading when taken out of context. Therefore, some of the quotes below may not reflect the authors' intentions. However, for our purposes let's assume the quotes below are the only information available concerning the programs from which the quotes were taken. Based on the information below, indicate on the response sheet:

A. The probable source of the majority of the objectives of the program from which each quote was taken.

B. What is to be emphasized by teachers who use the programs.

1. . . . the complex set of skills a scientist uses in conducting a scientific investigation are broken down into a number of processes which must be mastered if the learner is to develop a sound knowledge of science and its methods.

2. This edition of Charting the Universe, like those of preceding years, represents a new organization of science content based on an identification of fundamental astronomical ideas.

3. . . . interweaves topics from the broad areas of Space, Time, Energy, and Matter in an integrated program for kindergarten through grade six.

4. . . . explains fundamental concepts and basic principles that have long been known to scientists. In addition, the book goes into theories and discoveries that have been around for scarcely a decade. Thus, in your study . . . you will explore both the foundations of science and the frontiers of modern science.

5. Of course . . . personnel have some ideas about what constitutes good science for children. Philip Morrison, one of the prime movers of . . . has provided a clue to what . . . considers important when children and science meet:

   > One mandate is imperative for our style of
   > work: there must be personal involvement.
   > The child must work with his own hands,
   > mind and heart.

Indeed getting children totally involved in working with materials is what gives directions to the development of . . . materials. And this involvement criterion is determined to a large extent not by theoretical assumptions about what interests children but how children actually respond to materials during the developmental process. If the materials fail to turn children on, affectively and cognitively, the idea under consideration is discarded and others are pursued.

6. The . . . has recently initiated an evaluation program to make an appraisal of . . . units effects upon the children studying them . . . The Relativity (name of a unit) tests measured the child's conceptions of relative motion, relative position, configuration and corresponding observers, and spatial perspectives. The children were asked to solve a number of problems to assess their understanding of the above concepts.

7. This program is based upon the structure of science as seen by modern scientists. . .

8. In developing units for the SCIS physical science program, we consider two criteria: The units must provide interesting activities which inspire the children to undertake investigations, and it must have a natural place in the conceptual framework of the program. This framework requires that the introduction of each new unit be considered with respect to what has gone before and what is intended to follow. Not only should the concepts be introduced in what we consider to be their natural order, but they also must be presented at a point when the child has the necessary intellectual abilities to take advantage of them.

9. The most striking characteristic of these materials is that they are intended to teach children the processes of science rather than what may be called science content. That is, they are directed toward developing fundamental skills required in scientific activities.

10. . . . is a point of view in science education for the elementary school. It is based on the assumption (and frequent observation) that if the objects in a child's environment are carefully selected and sequenced, the child can assume the responsibility for deciding which activities are appropriate and meaningful for him. He can decide what to do to the objects in his environment; he can decide how much of each activity is appropriate for him. He can invent activities which no curriculum developer or teacher could have invented for him. He can do these things only if his environment does not propose a threat. This rules out instructional techniques that motivate by promise of external rewards or punishment.

Sources of Objectives and Emphases in Science Education

Objective 3 - Pretest

State below the emphasis in science which you tentatively believe to be the most appropriate for the grade(s) which you teach, or hope to teach:

Preferred Emphasis ______________________________

Complete the following:

I favor the above emphasis because:

1. ______________________________
____

2. ______________________________
____

3. ______________________________
____

I tentatively reject the ______________ emphasis because:

1. ______________________________
____

2. ______________________________
____

I also tentatively reject the ______________ emphasis because:

1. ______________________________
____

2. ______________________________
____

Sources of Objectives and Emphases in Science Education

Objective 1 - Post-test

In the spaces below, name the four primary sources of science education objectives, and name the emphasis related to each of the three major sources.

Source of Objectives	Related Emphasis
1A____________________	1B____________________
2A____________________	2B____________________
3A____________________	3B____________________
4A____________________	

- -

Objective 2 - Post-test - (Response sheet - test follows)

Source of Objectives	Related Emphasis
1A____________________	1B____________________
2A____________________	2B____________________
3A____________________	3B____________________
4A____________________	4B____________________
5A____________________	5B____________________
6A____________________	6B____________________
7A____________________	7B____________________
8A____________________	8B____________________
9A____________________	9B____________________
10A____________________	10B____________________

Sources of Objectives and Emphases in Science

Objective 2 - Post-test

Below are quotes from various elementary science program materials. Such quotes are sometimes misleading when taken out of context. Therefore, some of the quotes below may not reflect the authors' intentions. However, for our purposes assume the quotes below are the only information available concerning the programs from which the quotes were taken. Based on the information below, indicate on the response sheet:

A. The probable source of the majority of the objectives of the program from which each quote was taken.

B. What is likely to be emphasized by teachers who use the programs.

1. In the intermediate grades the children should acquire the use of more complex and integrated process abilities which are an extension and an elaboration of the skills developed in the primary grades.

2. Every scientist, from the anthropologist to the zoologist, makes use of certain definable intellectual tools in the investigation of natural phenomena. These tools include observing, classifying, measuring, inferring, predicting, interpreting, hypothesizing, etc. A key objective of . . . (this program) is to teach these skills--to develop specific competencies in these behaviors in children beginning at kindergarten level.

3. The hierarchy of concepts, ranging from the very basic concepts in primary units to the more sophisticated concepts of the physical and life sciences, reflects the concern that children's science experiences be consistent with the nature and structure of science.

4. Teaching Tests . . . are available separately for grades 3-6. The answer keys are found in the teacher's editions of the manuals. These tests, to be used after each unit, go beyond the testing of facts. Like other elements in the program, they help teachers evaluate the pupils' understanding of concepts. The questions for each test are designed to evaluate comprehension as well as retention of information.

5. The . . . has designed its units so that the concepts used become increasingly complex as the children mature. Later concepts such as energy and natural selection are built on earlier ones such as systems and organisms. The overall program is a hierarchy structured around the fundamental concepts of both physical and biological sciences, and organized into ascending levels of abstraction.

6. The most striking characteristic of these materials is that they are intended to teach children the processes of science rather than what may be called science content. That is, they are directed toward developing fundamental skills required in scientific activities.

7. The . . . consists of two series of related sequential units. One unit in life science and one in physical science are paired for each of six levels. Taking advantage of the natural curiosity of children, . . . presents a wide variety of phenomena for classroom exploration and investigation. At each of the six levels numerous inquiry-oriented activities help children accumulate experiences and ideas which advance their thinking from the concrete to the abstract, and enable them to relate scientific concepts to the everyday world.

8. From the Table of Contents of an elementary science unit:

   Chapter 3. Where is the Sun?
   The Milky Way
   Star Gauges
   Help from the Globular Clusters
   A Dusty Galaxy

9. . . . facilitates for each child the development of a positive self-concept with regard to independent learning and the manipulation of his environment.

10. Granted the premise that some understanding of science is important for everyone, the question then follows, "What is the best way to help students attain a level of understanding and appreciation of the scientific enterprise that will serve them through their adult lives?" Our answer is to focus their attention on the "great ideas" in science, the broad, inclusive conceptual schemes in terms of which we seek to account for the familiar facts of nature. Such unifying ideas as the kinetic-molecular theory, the statistical view of the universe, the conservation principles, the gene theory of heredity, etc., are the main goals of science and we believe should form the core of the science curriculum.

Sources of Objectives and Emphases in Science Education

Objective 3 - Post-test

State below the emphasis in science which you tentatively believe to be the most appropriate for the grade(s) which you teach, or hope to teach:

Preferred Emphasis ______________________________

Complete the following:

I favor the above emphasis because:

1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

I tentatively reject the ______________ emphasis because:

1. ______________________________

____

2. ______________________________

____

I also tentatively reject the ______________ emphasis because:

1. ______________________________

____

2. ______________________________

____

Differentiating Between Product- and Process-Centered Instructional Objectives

This exercise was written primarily to enable the reader to be able to:

1. Given a list of instructional objectives, distinguish between objectives which are primarily product-centered and objectives which are primarily process-centered.

Until a few years ago, most science education objectives were derived from an analysis of subject matter, and the products of science (or "content" or "subject matter") were considered the major component of what was to be taught and learned in science. It was more or less taken for granted that students would learn certain basic ideas concerning things such as heat, light, weather, the solar system, and plants and animals. Some basic science information, or some products of science which children might have learned, are as follows:

1. Rays from the sun come through space as radiant energy.
2. The nucleus of an atom exerts a force of attraction on the electrons surrounding it.
3. There is a very large magnetic field about the earth.
4. Moving water in streams can wear away or build up the land.
5. There is a constant movement of materials into and out of the cells that form an animal's body.

Today, some persons are advocating that a different kind of "content" be included in science programs. This new "content" is called the processes of science. Objectives which have been derived from an analysis of the way scientists think and work are said to be process-centered rather than product-centered.

Today's science teachers must choose between product- and process-centered objectives, or choose some of both, if they teach for student mastery of teacher-selected instructional objectives.

The term "processes of science" has been popularized by the American Association for the Advancement of Science (AAAS). This organization of scientists and science educators developed a K-6 elementary science program and named the program Science-A Process Approach. In the SAPA program, process is more of an emphasis (ends) than an approach (means). The objectives in the program are said to emphasize the processes of science rather than the products of science.

As used in the AAAS materials, processes of science are intellectual skills or tools. In one brochure publicizing the Science-A Process Approach program it is stated:

> Every scientist, from the anthropologist to the zoologist, makes use of certain definable intellectual tools in the investigation of natural phenomena. These tools (processes or behaviors) include observing, classifying, measuring, inferring, predicting, interpreting, hypothesizing, etc.[1]

Process, as it is used in the Science-A Process Approach program, is defined in three ways in still another brochure. The definitions are:

> There are a number of ways of conceiving of the meaning of "process" as exemplified in Science-A Process Approach. First, perhaps, it should be mentioned that an emphasis on process implies a corresponding de-emphasis on specific science "content" (products of science). Of course, the content is there--the children examine and make explorations of solid objects, liquids, gases, plants, animals, rocks, and even moon photographs. Rather, they are expected to learn such things as how to observe solid objects and their motions, how to classify liquids, how to infer internal mechanisms in planets, how to make and verify hypotheses about animal behavior, and how to perform experiments on the actions of gases. For example, in an exercise on the movement of liquids in materials, the children learn to design and carry out experiments on the relation between kinds of materials and rate of movement of liquids within them, including the control and manipulation of relevant variables; but they are not required to learn particular facts about the rate of liquid movement in blotting paper, fabrics, sand, clay or other materials employed in the exercise. Such facts may be incidentally learned, and may be useful to the child, but the primary objective is one of learning to carry out the process of controlling variables in an experiment.
>
> A second meaning of process . . . centers upon the idea that what is taught to children should resemble what scientists

do--the "processes" that they carry out in their own scientific activities. Scientists do observe, and classify, and measure, and infer, and make hypotheses, and perform experiments. How have they come to be able to do these things? Presumably, they have learned to do them, over a period of many years, by practicing doing them. If scientists have learned to gain information in these ways, surely the elementary forms of what they do can begin to be learned in the early grades. This line of reasoning does not imply the purpose of making everyone a scientist. Instead, it puts forward the idea that understanding science depends upon being able to look upon and deal with the world in the ways that the scientist does.

The third and perhaps most widely important meaning of process introduces the consideration of human intellectual development. From this point of view, processes are in a broad sense "ways of processing information." Such processing grows more complex as the individual develops from early childhood onward. The individual capabilities that are developed may reasonably be called "intellectual skills," a phrase which many would prefer to the term "processes."[2]

While these definitions are helpful, they do not help the teacher who might want to emphasize the processes of science in his teaching and treat the products of science in an incidental manner. It seems that if you want to be able to teach for process or product learnings, you must be able to identify a process- or product-centered instructional objective, and then develop or select curriculum materials in which is emphasized the type of learning you prefer.

A recent study indicated that there is considerable disagreement among science educators concerning what constitutes product- and process-centered objectives.[3] Therefore, you should not feel badly if you someday find that you are not sure whether you are teaching for product or process learnings.

Processes of science are said to have transferability.[4] That is, skills or processes, once acquired, can be used in many different situations. For example, one process or skill is constructing predictions using a graph. One could use a graph and construct predictions concerning plant growth, temperature, a decline in population of a group of organisms, rate of heart beat, etc.

In this exercise, let's use a set of criteria based on the idea of transferability to differentiate between product and process objectives. Let's label an objective as being primarily process-centered if:

1. The skill described in the objective has transferability, that is, the skill can be used in many different areas of science or in different situations in one area of science.

2. The skill described in the objective can be practiced, that is, many different situations could be set up in order to provide children with practice until they have mastered the skill at a predetermined level of proficiency.

3. The objective does not include reference to specific products of science.

Let's label an objective as being primarily product-centered if:

1. The basic idea in the objective does not have transferability.

2. The basic idea does not lend itself to practice.

3. The objective includes reference to specific products of science.

Now let's try these criteria on a set of objectives. Below are five objectives. Which are process-centered and which are product-centered (according to the above criteria)?

1. Given a hypothesis that can be tested, design a laboratory procedure, or experiment, that will test the hypothesis.

2. Explain why an electrical circuit is a system of interacting objects.

3. Classify common substances as elements or compounds when given symbols, formulas, or models.

4. Construct an operational definition of an object in descriptive terms.

5. Predict which of several objects will accelerate most when given the mass of the objects and the size and direction of the force applied.

According to the criteria being used in this exercise, objectives one and four are primarily process-centered and the others are primarily product-centered. In objective one, the given hypothesis could relate to any field of science, many hypotheses could be given; therefore, practice could be provided, and the objective does not include reference to specific products of science. In objectives three and five, a number of different substances and objects could be used; however, both objectives involve knowledge of specific products of science.

Is the following objective primarily product- or process-centered--according to our criteria?

> Identify whether or not an observation supports a stated hypothesis, or an inference based on a hypothesis, about conductors and non-conductors.

The first two-thirds of the objective seem quite process-centered. However, the portion "about conductors and non-conductors" limits the transferability of the skill and requires learners to have knowledge of specific products of science. Therefore, according to our criteria this objective is primarily a product-centered objective. (Although some process is involved.)

Below are ten objectives. Number your paper to ten and indicate which are product-centered and which are process-centered by writing Pt (for product) and Ps (for process) after the numbers.

1. Explain the differences between blood and lymph, including their parts and major functions in the human body.
2. Given two states of matter, tell whether heat must be added or taken away to go from the first to the second state.
3. Explain the way two variables on a graph of data are related.
4. Classify animal mothers into (1) mothers who have living babies, and (2) mothers who lay eggs.
5. Given an object or substance to be measured, select the appropriate measuring instrument.

6. Explain the relationship that might exist between two given variables in an experiment.

7. Given a specific concept or science principle, locate related information in at least three different sources.

8. Explain how body coverings help animals to adapt to certain climates.

9. List the things soil must contain to make plants grow well.

10. Given a description of a regularly occurring event, state at least two probable consequences.

According to our criteria, statements one, two, four, eight, and nine are primarily product-centered, and the others are primarily process-centered. If you disagree on one or more of the objectives, ask yourself these questions:

1. Can the idea or skill be used in a variety of situations--does it have transferability?

2. Could practice (not repetition) be provided?

3. Are specific products of science referred to?

If you need more practice, try these: Number your paper to ten and use Pt for product and Ps for process.

1. Distinguish between minerals having metallic and non-metallic luster.

2. Given a diagram of a skeleton, locate four kinds of joints.

3. Construct a hypothesis from a given set of observations.

4. Describe possible geographic reasons that prehistoric plants and animals are no longer living.

5. Explain how an experiment shows that heat is a form of energy.

6. Given a set of data, and the procedures used in gathering the data, follow the procedures and gather similar data and account for possible differences in the data collected and the given data.

7. Tell why a person needs nutrients and how they differ from wastes.

8. Differentiate between observations and inferences.

9. Given a statement concerning information in a histogram, identify the information that supports the statement.

10. Identify the variables that might affect the time a round object takes to roll down an inclined plane.

Statements three, six, eight, and nine are primarily process-centered and the others are primarily product-centered--according to our criteria. Statement ten involves a thought process (identifying variables), but this objective does not meet our criteria of lending itself to practice and having transferability.

Summary

In planning for science, today's teachers have three major sources from which to derive objectives, or they may choose a commercial program with objectives which have been derived from one of the three major sources. The three sources of objectives are: subject matter, the way scientists think and work, and children.

When objectives have been derived largely from an analysis of subject matter, the products of science are emphasized. When objectives have been derived largely from an analysis of the way scientists think and work, the processes of science are emphasized. When objectives are derived from the developmental needs of children, the products and processes of science become vehicles (means rather than ends) through which other objectives are met. Most of the objectives in most of today's elementary science programs are product- or process-centered. Most programs contain objectives of both types.

It is believed that science education will be improved if teachers know the nature (product-, process-, or child-centered) of the objective toward which they are working and if the type of objectives toward which they are working is consistent with their preference.

References:

1. *Science-A Process Approach*, (Program brochure) (New York: Xerox Corporation, 1967), p. 2.

2. *Science-A Process Approach: Purposes - Accomplishments - Expectations*, (Washington: American Association for the Advancement of Science, Washington, D. C., 1967), pp. 3-4.

3. John F. Newport, "Process: What Is It?" Paper presented at the NSTA North Central Area Convention, St. Louis, October 6, 1972.

4. Robert M. Gagne, "Elementary Science: A New Scheme of Instruction," *Science*, 151 (Jan. 7, 1966), 49-53.

Differentiating Between Product- and Process-Centered Instructional Objectives

Pretest

Place Pt before each instructional objective below which is largely product-centered and place Ps before each objective which is largely process-centered.

____ 1. Describe the expected outcomes of future tests based upon inferences.
____ 2. Identify the variables that are manipulated (changed) in an experiment.
____ 3. Recognize that the dragonfly nymph is a predator.
____ 4. Identify changes in objects by using at least three senses.
____ 5. Identify subsystems that show evidence of interaction.
____ 6. State that bodies in space, as well as their matter and energy, are in constant change.
____ 7. State in writing how chromosomes duplicate in cell division.
____ 8. List three specific functions performed by plant cells.
____ 9. Given a diagram of a flower, label the various parts correctly.
____10. Measure a specified object to the nearest specified unit.
____11. Given a set of data, construct a bar graph.
____12. Given three organisms sharing the same ecological environment, describe how the three are dependent upon each other.
____13. Differentiate between static and current electricity.
____14. Revise a prediction on the basis of additional data.
____15. Given a statement and a set of data, identify the data that support the statement.

Differentiating Between Product- and Process-Centered Instructional Objectives

Post-test

Place Pt before each instructional objective below which is largely product-centered and place Ps before each objective which is largely process-centered:

_____ 1. Describe the major function of the pancreas.
_____ 2. Name the six simple machines.
_____ 3. State that as heat is applied, the molecules of water move faster and farther apart.
_____ 4. List the names of ten elements and their atomic numbers.
_____ 5. Distinguish between an operational and a non-operational definition of a given word.
_____ 6. Identify the variables held constant in an experiment.
_____ 7. Differentiate between kinetic and potential energy.
_____ 8. Construct an inference based on a hypothesis.
_____ 9. Distinguish between statements that support a hypothesis and those that do not.
_____10. Draw a diagram of the atom including electrons, protons, and neutrons.
_____11. Name the nine known planets in our solar system.
_____12. Explain what causes day and night.
_____13. Construct a classification system to be used in classifying a given set of objects.
_____14. Describe the relationship between two variables that can be used to make predictions.
_____15. Match causes of air pollution to forms of prevention.

Developing A Philosophy of Science Education

This exercise was written primarily to enable the reader to:

1. Given the name of two philosophical viewpoints toward science education, a list of statements from the professional literature and curriculum materials, and statements that might have been made by teachers, indicate which philosophical viewpoint is best reflected in each statement.

2. Tentatively adopt one of the two major philosophical viewpoints in science education and, given statements reflecting the two major viewpoints, identify statements that are consistent with the reader's choice of viewpoints.

3. State three reasons why one viewpoint was adopted and three reasons why the other viewpoint was rejected (six reasons in all).

Let's assume that we have either a child, a small group of children, or a whole class of students, some science materials, and a teacher and that these things are about to interact; that is, the "lesson" is about to commence. Obviously, the nature of the interaction that takes place depends largely upon the teacher because he is in charge and exercises control over the situation. Let's think of the type of interaction permitted, or planned by the teacher, which might take place as fitting somewhere on a continuum as below:

0 1 2 3 4 5 6 7

0	7
Pupil or pupils do not do anything with the materials except as instructed by the teacher, or by independent study materials.	Pupils are free to do anything they wish with the materials as long as safety precautions are observed, equipment is not intentionally damaged, and other pupils are not disturbed.

Most persons feel that some type of pupil-materials-teacher interaction somewhere between these two positions is more desirable than either of the two extremes. The nature of the interaction that takes place in your classroom will depend partly upon your philosophy and your ability and willingness to work to implement your beliefs, and partly upon the philosophy of other persons in your school who help select or develop science program materials which you may be required to use.

What do you believe concerning science for young children? You are probably unable at this time to state with much certainty what you believe. You may not have given this question much thought and think, "What difference does it make what I believe?" Since your actions in the classroom will be determined by what you believe, and since your actions will affect the lives of the children you teach, it makes a great deal of difference what you believe.

Do you believe that science is mainly something that is taught to children, or do you believe that science is mainly something that children engage in?

If you believe science is something that is taught to children, you probably also believe there is a set of facts, concepts, principles, etc., (products of science) and skills (processes of science) that are in your head (and in the teacher's manual and students' textbooks) that are to be "transferred" to the heads of your pupils. You know something the pupils do not. Therefore, you believe it is your job to instruct your pupils either individually, in small groups, or in one large group so they, too, will know what you know and what is in their books. If you believe something like this, it is difficult for you to make a case against the following:

1. State what is to be taught to pupils (purposes of the lesson or exercises) in precise (behavioral) terms.

2. Preassess students to determine their level of achievement prior to instruction.

3. Provide instruction or independent learning materials necessary to enable pupils to acquire the knowledge or skill described in the objectives of the lesson, or exercise.

4. When practice is called for, provide each pupil with a sufficient amount of practice to enable him to demonstrate mastery of the objective.

5. Evaluate in order to determine whether your instruction or independent study materials have enabled pupils to master the objective at the level you believe to be necessary.

6. Provide additional instruction and practice for those pupils who need it as indicated by the post-instruction evaluation instrument.

Persons who hold this viewpoint are primarily concerned that children know certain products of science and are proficient in certain processes of science after instruction has been completed. Therefore, let's label the approach used in implementing this viewpoint the instructional approach.

In the instructional approach, the sources of the majority of objectives are subject matter and the ways scientists think and work. The emphasis is upon either the products or the processes of science, or both. However, a few other objectives (psychomotor or affective) may be included.

There is another viewpoint toward science education which holds that the experiences which children have in science are more important in the long run than the products and processes of science that might be retained after the experience. Let's label the approaches used in implementing this viewpoint experiential approaches. (Note the spelling: It is e-x-p-e-r-i-e-n-t-i-a-l, not experimental.)

In the instructional approach, we know we want students to learn something, we should know what that something is, and we are (or should be) concerned with selecting or planning the most efficient instructional activities possible. We ask this question: In which activities can I have my pupils engage that will result in the greatest amount of learning in the shortest period of time?

In experiential approaches, we want students to engage in a (hopefully) intellectually stimulating and thought-provoking experience. We are concerned about such things as pupil interest, opportunities for them to express and develop their creativity, feelings of adequacy and inadequacy generated by the experience, opportunities for exploration, opportunities for sharing ideas with classmates, opportunities for manipulation of objects, opportunities to make choices, etc.

Whereas instructional objectives are the dominant feature of the instructional approach, materials and objects are the dominant feature of experiential approaches. The nature of the materials more or less dictates the experience pupils will have. If you want pupils to have a reading experience, furnish them with books. If you show a film, their experience consists of sitting and watching and listening. If you want your pupils to engage in an experience with batteries, bulbs, and wires, make those objects available.

Below are pairs of quotes which contrast the instructional and the experiential viewpoints. As you read each pair, decide which statement is easiest for you to believe. If you find yourself consistently believing in the statements which describe one of the approaches, you are in the process of formulating a consistent philosophy. If you find yourself believing in first one type of statement, then the other, you may have some "sorting out" to do in your thinking.

The Instructional Viewpoint Holds That:	The Experiential Viewpoint Holds That:
1. The ultimate purpose of education is primarily the acquisition of skills and the storage of information and its subsequent retrieval and use.	1. The ultimate purpose of education is primarily the development of children's intellectual, language, social, and emotional potentials.
2. Students are a product of external events to be molded and directed.	2. Children and their behavior essentially develop from within.
3. Teachers should set up an image of what students should be like, and then, with reinforcement techniques, shape them so that they become that image.	3. Teachers should permit children to choose many of their own ends, and help them become the best choicemakers it is possible for them to become.
4. Teachers should consider variations from their image of what students should be like as deficiencies to be overcome.	4. Teachers should consider variations in children's abilities and skills to be indicative of developed and undeveloped potential.

5. Most objectives should be derived from an analysis of subject matter and the ways scientists think and work.	5. Most objectives should be derived from an analysis of the needs of children.
6. The products and the processes of science should be emphasized.	6. The products and the processes of science should be used as vehicles through which other ends are met.
7. The structure of subject matter, or the unifying themes, or conceptual schemes, should be taught.	7. Children should be presented with a variety of situations where they are active and create structures consistent with their level of development.
8. The science which students learn should be "respectable" in the scientific community.	8. The activities in which children engage in science should be childlike in nature.
9. Science instruction should be facts and skills oriented--concerned with concrete and objective events.	9. Children's experiences should be meanings oriented--concerned with the perceptual experiences of children--how things *seem* to them.
10. Students should be primarily consumers of information relating to the products and process of science.	10. Children should be primarily producers of ideas and information.
11. Teachers should have many instructional objectives--most of which can be mastered by students in short periods of time.	11. Teachers should not prespecify objectives because prespecified objectives tend to limit creativity, exploration, and discovery.
12. Highly specific objectives should serve as end-points of instruction.	12. The growth of children should be considered continuous.

13. The focus is upon *teaching*.	13. The focus is upon pupil *growth* and *development*.
14. Teachers should mainly use those materials and equipment that are essential for student mastery of stated objectives.	14. Teachers should make available a variety of materials and equipment that provide many opportunities for manipulation and exploration.
15. Teachers should perceive the helping task as a matter of controlling and manipulating.	15. Teachers should perceive the helping task as one of freeing, assisting, releasing and facilitating.
16. Students should respond mainly to the teacher and to self-instructional materials.	16. The learning environment should respond to children's initiation and exploration.
17. Teachers or self-instruction materials should attempt to enable students to exhibit a specific behavior.	17. An environment should be provided wherein there are many opportunities for children to explore and interact with peers with a minimum of imposed structure.
18. Students should master an objective before moving on to the next objective in the sequence.	18. Breadth of problem-solving opportunities is more important than complete mastery.
19. Almost all students should emerge from a lesson with the same set of process skills or store of knowledge.	19. Children should emerge from an activity with their curiosity partially satisfied and partially stimulated so they want to know more.
20. The teacher's main concern should be for precision with respect to objectives, instruction, and evaluation.	20. The teacher's main concern should be for richness and diversity of experiences available to children.

Do you find yourself "leaning toward" the instructional or the experiential viewpoint? List on a separate sheet of paper the approach which you tend to favor at this time.

Next, number your paper from 1 - 10 and indicate which of the statements below that you tend to agree with.

1. One of the most important functions of teaching is to communicate ideas and information to students.

2. Delivery techniques, use of audio-visual materials, set induction, pacing, closure, planned repetition, and other skills are related to effective teaching.

3. . . . left to his own devices the child learns rapidly, in ways he will not soon forget, and in a manner which has highly practical meaning for him. . . all of this can be spoiled if he is "taught" in a way which involves only his intellect.

4. . . . if I trust the capacity of the human individual for developing his own potentiality, then I can provide him with many opportunities and permit him to choose his own way and his own direction in learning.

5. The elementary school should not be a storage time, but an insightful time, a time to acquire a taste for learning and the motivation to continue to learn.

6. The goal is not to get a "right" answer, but to find out what the children do think, and what progress they are making.

7. . . . if the objects in a child's environment are carefully selected and sequenced, the child can assume the responsibility for deciding which activities are appropriate and meaningful for him. He can decide what to do to the objects in his environment; he can decide how much of each activity is appropriate for him. He can invent activities which no curriculum developer or teacher could have invented for him.

8. The objective of the science program is to teach children to look at natural phenomena from the distinctive vantage point of modern science.

9. Good pedagogy must involve presenting the child with situations in which he himself experiments in the broadest sense of that term--trying things out to see what happens, manipulating things, manipulating symbols, posing questions and seeking his own answers, reconciling what he finds at one time with what he finds at another, and comparing his findings with those of other children.

10. Leadership by teachers who use their experiences and backgrounds to guide children into meaningful experiences is fundamental to a good program. When we urge children to make decisions for which they have no background, we are often wasting time and frustrating both ourselves and the children.

Now that you have indicated which of the above statements you agree with, indicate which viewpoint (use I for instructional and E for experiential) is reflected in each quote.

Before responding to the above exercise, you were directed to list the viewpoint you tend to favor at this time. If you listed the instructional viewpoint, you should have agreed with statements 1, 2, 8, and 10. If you listed the experiential viewpoint, you should have agreed with statements 3, 4, 5, 6, 7, and 9.

Below are some statements made by teachers. Which teachers would you be most interested in exchanging ideas with? Respond by first indicating which viewpoint you believe in (instructional or experiential), then check the statements that agree with the viewpoint that you listed.

1. "I think pretesting is a good idea, but I got tired of it real quick. I want to teach--not test all the time."

2. "I consider my teaching effective when 80% of my students master my objectives at a level of 80% or higher."

3. "I think the products of science should be included but the emphasis should be on the processes."

4. "I'm finding that my kids are choosing projects that take longer to complete than they did earlier in the year."

5. "I still have a few children who don't seem to know what to do with themselves, but the number is getting smaller each week."

The persons who made statements 1, 2, and 3 believe in or use an instructional approach, and those who made statements 4 and 5 believe in or use an experiential approach.

Now, for the difficult part of this exercise. *Why* do you tend to favor one viewpoint and tend to reject the other? Can you give three *reasons* why you prefer one viewpoint and three *reasons* why you dislike the other? Begin your reasons with these statements:

I favor the ______________ viewpoint *because*:

I reject the ______________ viewpoint *because*:

It takes time to develop into a good science teacher. You must formulate a philosophy, or accept a philosophical viewpoint, and then collect or develop materials to enable you to teach certain science products and processes to your pupils, or to enable you to provide your pupils with rich experiences in science--or some of both.

Hopefully, this exercise will enable you to identify professional books and articles and curriculum materials that are consistent with your developing philosophy. It should also enable you to quickly identify other teachers whose philosophy is similar to yours with whom to share ideas and materials.

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Developing a Philosophy of Science Education

Pretest - Objective 1

Below are statements from various sources. Indicate whether each statement reflects a belief in the instructional or the experiential philosophical viewpoint. (Use I for instructional and E for experiential)

____ 1. For . . . the objectives of instruction are capabilities. They are behavioral products that can be specified in operational terms. Subsequently, they can be task-analyzed; then they can be taught.

____ 2. Science teaching entails providing pupils with objects, materials, and equipment they can use to discover and create ideas. To learn about science is to develop an understanding of it, its structure and its methods, through inductive procedures. Programs in science are structured around essential concepts and methods of inquiring into the meaning of concepts. Learning becomes patterned to achieve these ends.

____ 3. Your students will profit from being allowed to go in directions as their explorations lead them. Children who become involved in building will really create their own unit through activities that mean the most to them.

____ 4. This science unit provides for many kinds of activities; teacher demonstrations, pupil experiments, pupil discussions, recording of observations, interpreting illustrations, and so on. The activities which have common objectives are grouped together into six major parts. These parts are divided into chapters according to the materials and equipment used. This guide provides background information for each part, lists the materials to be used in each chapter, describes teaching suggestions, and lists the major objectives of the children's learning experiences.

____ 5. This unit presents a number of activities and questions designed to provide children with a first look at the effects of heat, surface area, specific heat, and conductivity on melting rates. The unit can also help children begin to understand something about freezing point, freezing point depression, density, and the use of thermometers.

____ 6. The goal in education is not to increase the amount of knowledge, but to create possibilities for a child to invent and discover.

____ 7. Two major objectives of science education are to help the child develop (1) knowledge of science concepts - the content (products) of science - and (2) facility in scientific skills and attitudes - the processes of science and scientific inquiry. These objectives are essentially the same in the elementary and secondary school, the only difference being in how much and how well these objectives will be developed.

____ 8. Children's responses to the environment provide many of the starting points for learning. Activities most often arise from the needs and interests of the group rather than from a prescribed curriculum.

____ 9. The fact that children are active and involved does not in itself make a good program. How purposeful and meaningful these activities and involvements are determine whether or not they can be used as a measure of success. Let us keep asking ourselves, "What meaning have these experiences for children?" An activity without meaning to children is taking up valuable time in an already too crowded curriculum.

____10. When he (the student) chooses his own directions, helps to discover his own learning resources, formulates his own problems, decides his own course of action, lives with the consequences of each of these choices, then significant learning is maximized.

Developing a Philosophy of Science Education

Pretest - Objective 2

State on the line below which philosophical position (instructional or experiential) which you tend to believe in at this time.

____

Below are statements from various sources. Place a ✓ by those statements which are consistent with the philosophical position which you have tentatively adopted.

____ 1. Self-initiated learning, involving the whole-person of the learner, feeling as well as intellect, is the most pervasive and lasting.

____ 2. Little or no knowledge exists which it is essential for everyone to acquire.

____ 3. Programs in science should be structured around essential concepts, and learning should be patterned to achieve these ends.

____ 4. Each child should be free to explore an interest deeply and be free to disengage when an activity no longer seems appropriate.

____ 5. The science program should have balance. Equal emphasis should be given to the physical and the biological sciences in the over-all program. A balance in the length of units might be desirable so that some would be long and others would be shorter.

____ 6. Materials with "predetermined routes" are generally not desirable in that they usually do not lend themselves to broad exploration.

____ 7. Children will be likely to learn if they are given considerable choice in the selection of the materials they wish to work with and in the choice of questions they wish to pursue with respect to those materials.

____ 8. Those qualities of a person's learning which can be carefully measured are not necessarily the most important.

____ 9. To assure that at every point there will be a readiness for more advanced learning, the curriculum continuum needs to be planned to provide for increasingly complex inquiry skills as well as for growth in the meaning of the conceptual schemes.

____10. Decisions as to what comprises the basic structure of a discipline must be left in the hands of the practitioners in that discipline. In science, for example, this is the responsibility of the physicists, chemists, biologists, or other scientists. Once this structure is determined, the question of how to translate it into meaningful experiences for children of a given age group becomes real. This is the point at which the science education specialist working with the aforementioned individuals must further define the subject and the way of approaching it with the group of children for whom the curriculum is intended....

Developing a Philosophy of Science Education

Pretest - Objective 3

Complete the following statements:

I have tentatively adopted the ______________________ philosophical viewpoint because I believe:

1. ____
____
____

2. ____
____
____

3. ____
____
____

I have tentatively rejected the ______________________ philosophical viewpoint because I believe:

1. ____
____
____

2. ____
____
____

3. ____
____
____

Developing a Philosophy of Science Education

Post-test - Objective 1

Below are statements from various sources. Indicate whether each statement reflects a belief in the instructional or the experiential philosophical viewpoint as these terms are used in these materials. (Use I for instructional and E for experiential.)

____ 1. Children should understand not only the basic structure (of science) but also the rationale and way of thinking that characterize modern-day science. Not only should they be aware of and appreciate the accomplishments of, but they also need to realize the limitations of, science and scientists, especially when applied to problems which do not lend themselves to scientific analysis at the present time.

____ 2. There should be a time, much greater in amount than commonly allowed, which should be devoted to free and unguided exploratory work (call it play if you wish, I call it work). Children should be given materials and equipment--things--and are allowed to construct, test, probe, and experiment without superimposed questions or instructions.

____ 3. The extent of present-day knowledge demands that significant knowledge be taught as early in school as it can be comprehended.

____ 4. . . . a considerable part of class time must be spent in analyzing, organizing, and relating learnings until the student is able to form concepts and to recognize something of the nature of the subject. That is, until he has acquired an understanding of the process by which knowledge has been produced in the particular discipline. Only then can the student be said to truly possess any part of the subject.

____ 5. Children should be allowed to wrestle with problems and submit answers on their own level of operation and understanding. Therefore, teachers should try to tolerate uncertainty, tentative answers on big issues, and unresolvable questions. They can guide children to think about, to talk about, and to live with unfinished issues.

____ 6. Since it is no longer possible to teach any more than an exceedingly small fragment of any subject in a school year, and since the student will need an entrance into new knowledge for the rest of his life, the only apparent solution to the problem is to educate in terms of significant concepts, to develop skills in the processes and methods of science, and to provide experience in learning how to learn.

____ 7. A science curriculum should be designed to present instruction which is intellectually stimulating and scientifically authentic. It should be based upon the belief that an understanding of the scientific approach to gaining knowledge of man's world has a fundamental importance as a part of the general education of any child.

____ 8. A child who is learning naturally, following his curiosity where it leads him, adding to his mental model of reality whatever he needs and can find a place for, and rejecting without fear or guilt what he does not need, is growing . . .

____ 9. One of the most detrimental things done to the elementary school child is the incessant pursuit of the "right" answer. So many teachers enter the classroom with one major goal: to have the children parrot back "right" answers.

____10. Methods for evaluating pupils' achievement and progress should be an integral part of the science program.

Developing a Philosophy of Science Education

Post-test - Objective 2

State on the line below which philosophical viewpoint (instructional or experiential) which you tend to believe in at this time.

____

Below are statements from various sources (some of which have been changed slightly). Place a ✓ by those statements which are fairly consistent with the philosophical viewpoint which you have tentatively adopted.

____ 1. The objectives of a science lesson should be stated in terms of the processes and products of science.

____ 2. An important guiding purpose in developing a science program should be to provide the student in the elementary grades with some highly generalizable intellectual skills, and some knowledge of scientific procedures for gaining new knowledge, which can serve as a springboard for later study of any of the sciences. There are some very basic ideas which are important to the understanding of systematic science. . .

____ 3. Measures of achievement should be administered to children upon completion of an exercise or unit to obtain data on the number of children achieving the objectives. In most classrooms a high percentage of students should achieve the majority of the objectives.

____ 4. The science program for the elementary school child must provide interactive experiences of the child with selected segments of his environment that have the specific advantage of increasing the child's estimation of his own worth. By making and implementing his own decisions, the child will come to recognize the extent to which he can have an impact on his environment.

____ 5. Teaching and imparting knowledge make sense in an unchanging environment. But if there is one truth about modern man, it is that he lives in an environment which is continually changing. We are faced with an entirely new situation in education where the goal of education, if we are to survive, is the facilitation of change and learning. The only man who is educated is the man who has learned how to learn; the man who has learned how to adapt and change; the man who has realized that no knowledge is secure, that only the process of seeking knowledge gives a basis for security.

____ 6. . . . students who are in real contact with problems which are relevant to them wish to learn, want to grow, seek to discover, endeavor to master, desire to create, and move toward self-discipline.

____ 7. Experiments and demonstrations should not be performed without a specific purpose. They should be planned carefully and exactly. The necessary materials should be collected in advance and be ready for assembling or distributing so that there will be no delay or break in continuity of the learning situation.

____ 8. . . . sometimes one activity is enough for an understanding to be learned. Occasionally one good learning activity will suffice to produce the learning of more than one understanding, especially if the understandings are simple or are related to each other. Other times, when an understanding is difficult or abstract, more than one activity may be necessary to obtain adequate learning. Slow learners usually learn better when more than one activity is used.

____ 9. People grow, flourish, and develop much more easily when in relationship with someone who projects an inherent trust and belief in their capacity to become what they have the potential to become.

____10. Children are innately curious and will explore their environment without adult intervention. They display natural exploratory behavior if they are not threatened.

Developing a Philosophy of Science Education

Post-test - Objective 3

Complete the following statements:

I have tentatively adopted the ______________________ viewpoint (instructional or experiential) because I believe:

1. ____

____

____

2. ____

____

____

3. ____

____

I have tentatively rejected the ______________ philosophical viewpoint because I believe:

1. ____

____

____

2. ____

____

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3. ____

____

____

Identifying Guides To Be Used in Planning, Directing, and Evaluating Instructional Activities

This exercise was written primarily to enable the reader to:

1. Given a set of statements upon which the teacher's attention may be focused when planning, directing, and evaluating instructional activities, classify the statements using the following groups:

    A. A science problem
    B. A science question
    C. A behavioral objective
    D. A vague objective or an educational goal
    E. A science concept, principle, or generalization
    F. A means-oriented statement describing a student learning activity
    G. A means-oriented statement describing a teacher activity or responsibility
    H. None of the above

2. Given one or more elementary science teacher's manuals,

    a. Locate and list the statements in a specified chapter or section upon which the teacher's attention may be focused when planning, directing, and evaluating instructional activities, and

    b. Classify the statements using the categories in objective one.

If you were going bear hunting, would you choose to take along a high-powered rifle or a BB gun? If you set out to teach a set of science products and processes to a child, or to a group of children, would you rather "take along" a science problem, a science question, a behavioral objective, or some other type of statement?

Just as one must hunt a bear in a different manner with a BB gun than he would with a high-powered rifle, one usually teaches science differently with a science question than he does with a science problem, or with a specific or behavioral objective, or with some other type of statement.

Types of Statements

The chances are great you would "take along" a high-powered rifle to hunt a bear, and one or more of these statements when teaching certain products and processes of science to children:

A. A science problem
B. A science question
C. A specific or behavioral objective
D. An educational goal or vague instructional objective
E. A science concept, principle, or generalization
F. A statement describing a student activity
G. A statement describing a teacher responsibility or activity

Which of these you "take along" will most likely depend upon the instructional materials component of the support system supplied by your school. (Perhaps this exercise will influence your decision the next time you have an opportunity to select new instructional materials.)

Problems and Questions

For decades it has been recommended that children engage in activities in science, and that many activities center around the solving of problems. There has been an abundance of suggested science activities; but, unfortunately, real problems which are of interest to pupils and which result in pupils learning valuable products and processes of science have been in short supply.

What is a problem? What is a question? How do they differ? To my knowledge such a distinction has not been made in the professional literature. Therefore, let's attempt to differentiate between the two.

Below are two sets of complete interrogative statements. Examine them carefully and note how they differ.

Set A: 1. Do vibrating wires of different sizes make different sounds?
2. Do some metals conduct heat faster than others?
3. Will a hungry guinea pig travel through a maze faster than one which was recently fed?

Set B: 1. How fast does sound travel?
2. What would you need to live in space?
3. What plants are used to make medicines?

How do the two sets of statements differ? Does your explanation sound something like this: In the first set, students could do something to answer the statements. They could manipulate equipment. They could "experiment." They could find out by themselves.

Let's call statements problems which lend themselves to "experimentation," that is, statements which can be solved through direct experience and by the manipulation of equipment or objects. Children "experiment" in order to solve a problem.

Can the statements in Set B above be solved through "experimentation"? No, they cannot. Let's call statements such as those in Set B above questions. Questions are answered by reading or by asking someone who knows, or by watching a film, television, or filmstrip. Questions usually call for the student to be a passive receiver or gatherer of information.

Below are some complete interrogative statements. Number your paper to 10 and place a "P" before the number of each statement that is a problem and place a "Q" before the number of each statement that is a question according to the definitions above.

1. Do all liquids evaporate at the same rate?
2. Of what advantage is the radiosonde?
3. What are the two main motions the earth goes through?
4. Does air expand when heated?
5. What animals lived during the Cenozoic era?
6. What is the solar system?
7. Can a needle be magnetized?
8. Will bread mold grow on dry bread?
9. What factors influence the rate at which cylinders roll down an incline?
10. Is the earth round?

You should have indicated that 1, 4, 7, 8, and 9 are problems and the others are questions. Look back at any you might have missed and examine them carefully. Why did you mark them as you did? Do they lend themselves to finding out by "experimentation" through the use of objects, or do they orient one toward books, films, authorities, etc.?

The question of the availability of equipment is generally raised when persons respond to exercises such as that above. A statement may be either a problem or a question (according to the definitions used here) depending upon whether or not the necessary equipment is available. The same is true regarding the ability of teachers to guide pupils in the use of equipment that is available. According to our definitions of problem and question, a statement might be a problem in a classroom in which the necessary equipment is available and the teacher knows how to direct pupils in its use. The same statement might be a question in another classroom in which equipment was either not available or was available but the teacher does not know how to direct pupils in using it.

If a teacher wants an activity-centered science program, should he choose instructional materials which have lessons or independent learning exercises developed around problems or questions? Since problems lend themselves to "experimentation" involving the manipulation of objects, most persons would answer problems.

Objectives and Other Statements

In addition to science problems and questions, or in place of them, teachers might use other types of statements to guide their thinking as they plan for instruction and during instruction and evaluation. An examination of science teachers' manuals, teachers' lesson plans, independent learning materials, and learning contracts reveals that a number of different types of statements are used. Most of the statements are one of these five types:

1. Some statements describe desired post-instruction student capabilities in precise terms. This type of statement is commonly referred to as a behavioral objective. An example of this type of statement is: "After instruction, students should be able to construct an inference based on a hypothesis about conductors and nonconductors."

2. Some statements intended as objectives describe post-instruction student capabilities in very general or vague terms. A broad, general statement of this type is commonly referred to as an educational goal and more specific statements of this type are called vague objectives. Examples of this type of statement are: "Students should appreciate the contributions of science to our daily lives." and "Students should understand the function of various electrical components."

3. Some statements intended to guide the teacher's thinking concerning instructional activities are science facts, concepts, principles, or generalizations. An example of this type of statement is: "Sound travels in all directions from the source."

4. Some statements intended as a guide to the teacher describe activities in which pupils will engage *during* instruction. An example of this type of statement is: "Children investigate the solar cell which converts the sun's energy directly to electric energy."

5. Some statements that are listed as objectives or purposes relate to what the teacher is to do rather than to what the learner is to learn. An example of this type of statement is: "To help pupils learn the main plant structures and relate them to plant activities."

Although statements oriented toward teacher responsibility or activities (No. 5 above) and means-oriented statements which describe pupil activities (No. 4 above) seem less defensible as guides to instruction than broad educational goals or vague objectives, these types of statements have drawn little attention or criticism in the professional literature. However, much space has been devoted to making a case for and against specific (behavioral) and vague objectives, to helping teachers differentiate between the two, and to enabling teachers to write specific or behavioral objectives.

What is a behavioral objective? Since there is an abundance of material already available which answers this question, and since you are probably already somewhat familiar with behavioral objectives, only a review of some basic ideas will be given.

A behavioral objective is a statement which describes in precise terms what the learner should be able to do after instruction. The key word in a behavioral objective is a verb. In stating behavioral objectives a verb is used which specifies *observable* student behavior, or which specifies a *product* of student behavior that can be observed--such as a chart.

Writers of the Science-A Process Approach program identified nine verbs which are synonyms for many other verbs which might be used in writing behavioral objectives. The nine verbs and some synonyms are:

1. Identify - pick up, select, hold, point to and choose
2. Name - call, tell, and fill in
3. Order - arrange, place in position, classify, rearrange, and categorize
4. Demonstrate - show and illustrate
5. Construct - design, make, formulate, build, draw, produce, and modify
6. Describe - tell about, relate, give in own words, explain, and specify
7. Distinguish - differentiate, discriminate, detect, contrast, set apart, and separate
8. State a rule - quote
9. Apply a rule - use, calculate

Note that in each case in which a child engages in a behavior named by one of the words above, we could observe him or observe something he constructed, drew, built, etc.

Below are two objectives. One is behavioral and the other is vague.

A. To learn to count.
B. To name in order the numerals from 0-10.

Which objective above:

1. Best describes what pupils should be able to do after instruction?
2. Best defines the instructional task ahead for the teacher?
3. Best communicates to the student the purpose of his learning activities?
4. Permits precise evaluation; i.e., a teacher would be able to tell which students have mastered the objective and which students have not mastered the objective so remedial instruction could be provided when needed. (Objective B best does these things.)

Here are three behavioral objectives. Note the underlined verbs that denote observable student behavior.

1. Describe enough properties of an object to enable another person to identify the object.
2. Order objects according to weight by making comparisons using an equal-arm balance.
3. Distinguish between living and nonliving things in an aquarium.

Here are three objectives which are not behavioral. Note the verbs which do not name observable student behavior:

1. Understand the properties of objects.
2. Know how to weigh things with an equal-arm balance.
3. Realize that an aquarium contains different types of things.

Which of the objectives below are behavioral? (Remember, a behavioral objective describes observable student behavior--you will be able to see the student perform a task), or a product resulting from the student's behavior (a paper or some type of object such as a map or an animal cage). Respond by numbering your paper to 10 and placing a "B" by the number of each behavioral objective.

1. Make and demonstrate the use of a system for classifying substances that are solids, liquids, or gases.
2. Construct a bar of appropriate height on a bar graph to represent the number of a given set of objects.
3. Learn that there are three states of matter.
4. Understand that objects in nature vary in number.
5. To make sure that pupils see the difference between the first quarter and the last quarter of the moon.
6. To know that living things are adapted by structure and function to their environment.
7. State in writing three ways in which a given animal is suited to the environment.
8. To realize that the amount of energy gotten out of a machine does not exceed the amount put into it.
9. To identify objects in pictures and drawings which have either potential or kinetic energy.
10. Construct predictions based on data in a bar graph.

You should have indicated statements 1, 2, 7, 9, and 10 are behavioral objectives. A teacher can observe a student "make and demonstrate" as in 1; he can observe the bar graph in 2; he can observe the student's written paper in 7; he can observe the child as he identifies (points to, picks up, etc.) objects in 9; and he can observe either verbal or written predictions in 10.

Which type of statement, a behavioral objective or a vague objective, would best serve as a guide to the teacher in planning for instruction and during instruction, to pupils during learning activities, and to the teacher when evaluating when the teacher's main intention is to teach students certain products and processes of science?

Will one of these statements serve as a better guide than a science problem or science question?

Another type of statement that is intended to serve as a "guiding light" is statements of science concepts, principles, and generalizations. These statements are usually listed as "main ideas" or as "concepts to be developed." Some examples are:

1. Our solar system is made up of the sun, nine known planets, and their moons. The planets and moons receive heat and light as they move around the sun.
2. Clay is a sedimentary material which may or may not have become rock.
3. Mammals are warm blooded and suckle their young; most of them are born alive.
4. Heat can be radiated and reflected.
5. Most simple machines change either force or speed.

These statements indicate quite clearly some of the products of science that pupils are to learn. Certainly the first question that must be answered when using an instructional approach is: Which products and processes do I want my pupils to learn. A second question is: What kind of activities shall I plan so they do learn. And a third question is: How shall I evaluate so that I can tell whether or not they have learned. Which type of statements considered thus far best serves as a guide to the teacher in answering these three questions?

Still another type of statement intended to guide the teacher's thinking is a description of a student activity. These statements are sometimes listed as "objectives." Note in the examples below that these statements appear to be means rather than ends oriented:

1. To experiment with various objects in order to observe changes in them.
2. Pupils should discover that objects can be placed in several groups.
3. To practice writing numerals in scientific notation.
4. To investigate the field of a magnet system by using a compass and/or iron filings.

How well do you think this type of statement serves as a guide to the teacher when planning for instruction, during instruction, and when evaluating to determine the level of student mastery?

Some teachers' guides and manuals contain statements intended as guides to instruction that are different from those considered thus far. Some of these statements describe a responsibility of the teacher or an activity in which the teacher will engage. Some statements of this type are as follows:

1. To introduce pupils to the work of Marie Curie and Enrico Fermi.
2. To motivate pupil interest in classifying and identifying things and to lay the groundwork for a class project.
3. To interest the pupils in discovering the earth's true characteristics.
4. To help pupils understand the nature and origin of rocks.
5. To guide the pupils to an understanding of changes of state as changes in the arrangement of molecules.

It is obvious that in the examples above the teacher is the one that will "introduce," "motivate," "interest the pupils," "help pupils," and "guide pupils." Are these statements more like behavioral objectives or vague objectives? Does this type of statement serve as a good guide to the teacher in planning for instruction and during instruction and evaluation?

Practice. Below are some statements. Match them with the following: (Punctuation marks which might serve as clues have been omitted.)

A. A science problem
B. A science question
C. A behavioral objective
D. A vague objective or educational goal
E. A science concept, principle, or generalization
F. A statement that describes a student activity
G. A statement that describes a teacher responsibility or activity
H. None of the above

1. What is friction
2. Do different size vibrating wires make different sounds
3. Does sound travel in a vacuum
4. To teach the difference between blood and lymph
5. Identify systems of objects that interact at a distance
6. To help pupils learn that air expands when heated
7. What happens when a volcano erupts

8. All plants and animals need air
9. Construct a closed circuit
10. To review with students the metric system of measurement

The correct responses are: Number two is a science problem. One, three, and seven are science questions. Five and nine are behavioral objectives. None of them is a vague objective. Four, six, and ten describe a teacher responsibility or activity. None describes a student activity (other than those that are behavioral objectives which describe what students should be able to do after instructional activities are completed). Statement eight is a science concept. . . .

Try these. Match them with the choices above:

1. What makes the wind blow
2. Do mealworms prefer Wheaties or Cheerios
3. Understand the effects of gravity
4. When was the last ice age
5. To present pupils information concerning reproduction in lower forms of animals
6. To experiment to find out which of three liquids is the most viscous
7. How is an astronaut protected during re-entry
8. Calcium undergoes changes within the earth's crust
9. To introduce the pupils to the set of non-seed-producing plants
10. What kinds of materials do magnets attract

The correct answers are: 1-B, 2-A, 3-D, 4-B, 5-G, 6-F, 7-B, 8-E, 9-G, 10-A.

When instructing pupils with the intention that they actually learn teachers must make certain decisions. Among them are:

1. What pupils are to learn.
2. How pupils are to learn, that is, which instructional activities to plan for pupils to engage in that will result in student learning.
3. How to evaluate in order to determine whether or not pupils have learned, and whether or not the teacher's instructional activities were effective.

In selecting the curriculum materials component of a science support system, teachers must choose between materials which have been developed around various types of statements that might assist the teacher in making the three decisions above, or in implementing the program when the decisions have been made for the teacher by curriculum developers. Some types of statements serve better than other types as guides to teachers in making decisions required in the instructional approach, or in implementing instructional materials.

Locating Guiding Statements in Curriculum Materials

If possible, obtain some teachers' guides or manuals for use in teaching elementary science and examine them for statements which might serve as a guide to the teacher in planning, directing, and evaluating instructional activities. You will note that some guides or manuals contain only one of the types of statements being considered, some contain a number of the different types of statements, and some may contain statements not being considered here.

One manual[1] contains the following information in a prominent place in one section:

> OBJECTIVES
>
> After completing this exercise, the child should be able to:
>
> 1. CONSTRUCT representations of microscopic observations.
>
> 2. CONSTRUCT an operational definition of an object in descriptive terms.

These statements should be of much use to the teacher in planning, directing, and evaluating instructional activities. Which type of statements are the above? Obviously, they are behavioral objectives.

One section of another manual[2] contains the following:

OVERVIEW OF UNIT

1. What is chemistry?
2. What are some important substances?
3. What is the importance of carbon?

These statements are science questions.

A section of another manual[3] contains these statements:

OBJECTIVES

To identify stages in the life cycles of frogs, fruit flies, mealworms, and other animals.
To arrange in sequential order pictures of stages in the life cycle of a common animal.
To understand and use the term life cycle to refer to the developmental sequence of plants and animals.

These statements are somewhat difficult to classify. They are listed as objectives; therefore, they should be either behavioral or vague objectives. If they are considered objectives or things pupils should be able to do after instruction in that they are ends of instruction, the first two would be considered behavioral objectives and the third is a vague objective.

Another manual[4] contains statements upon which the teacher's attention might be focused under these four headings:

1. PURPOSE (purpose of a unit composed of a number of chapters.
2. PURPOSE (purpose of a chapter within a unit).
3. BEHAVIORAL GOALS (goals or objectives for a specific chapter).
4. MAJOR CONCEPTS DEVELOPED (concepts to be developed in certain sections of a chapter.

Below are examples of statements listed under each of the above headings:

PURPOSE (of Unit 3)

The content and organization of Unit 3 are designed to develop in pupils an understanding of (1) the appearance and the makeup of the earth and (2) how the earth changes in its appearance and makeup.

PURPOSE (of Chapter 7 in Unit 3)

This chapter is designed to provide the pupils with information concerning (1) the appearance of the earth's surface and (2) the general makeup of the earth's interior.

BEHAVIORAL GOALS

After the pupils study this section, they should be able to:

1. Make inferences after careful observations and collections of data rather than after casual observation.
2. Recognize cause and effect in inferring the makeup of the earth's interior.
3. Describe some of the general properties of the earth.
4. Name the layers of the earth's interior and list a few major properties of each.
5. Make models of the earth to aid in visualizing structure and space relationships.

MAJOR CONCEPTS DEVELOPED (on pages 68-71 of Chapter 7)

1. There are three main layers of the earth--the core, the rest of the interior, and the crust.
2. A layer of atmosphere surrounds the earth.

What types of statements are each of the above? Those listed under PURPOSE OF THE UNIT appear to be vague objectives or educational goals. Those listed under PURPOSE OF THE CHAPTER do not appear to be any of the types of statements being considered here. The words "This chapter is designed to provide the pupils with information . . ." so not relate to any of the types of statements being considered; therefore, it would be classified as "H--none of the above."

Statements three and four under the BEHAVIORAL GOALS heading are behavioral objectives. Some persons might classify statements one and two as behavioral while others might not. Statement five appears to be a description of a learning activity in which pupils will engage while enroute to mastery of the goals or objectives or purposes. The statements listed under the MAJOR CONCEPTS DEVELOPED heading would be classified "G--science concepts, principles, or generalizations."

Additional Learning Activity: Obtain different elementary science teachers' manuals (not more than one manual from any one program). From each manual, list examples of the types of statements being considered and classify them according to the groups listed in the objectives for this exercise. Then, schedule an appointment with your instructor to discuss your classifications.)

Summary

The authors of most elementary school science curriculum materials developed for use with an instructional approach in which certain products and processes of science are to be taught to children indicate in various ways what they consider to be the major ideas and skills to be taught when using their materials. Headings such as Goals, Objectives, Purposes, Major Concepts to be Developed, Processes Emphasized, Problems, etc., are used to alert teachers to the organizers or ideas and skills upon which their attention is to be focused when planning for instruction, during instruction, and when evaluating the effectiveness of instruction.

The nature of the statements upon which teachers are to focus their attention is important because the teaching-learning process is different with different types of statements. For example, the way a teacher teaches and the attitude of the teacher toward his students and his subject matter is quite different when he is helping his students master behavioral objectives than it is when he is guiding them as they solve a problem, or answer science questions, or work toward vague objectives, or when the teacher is "developing a topic" with his class.

Being able to differentiate between the various types of statements to be used as organizers by teachers should enable you to better select the science curriculum materials component of your support system, and should alert you to teaching strategies that are believed effective when teaching and using the various types of statements as organizers.

References and Sources of Additional Information:

1. Science-A Process Approach/Part E, Exercise V, (New York: Xerox Corp.), p. 1.

2. Willard J. Jacobson, et. al., Inquiring Into Science, Grade 5, (New York: American Book Company, 1965), p. vi.

3. Life Cycles, (Teacher's Guide), Science Curriculum Improvement Study, (Chicago: Rand McNally & Company, 1970), p. 40.

4. Herbert A. Smith, et. al., Modern Science (Level Four), (River Forest, Ill.: Laidlaw Brothers, 1972), pp. T63-T65.

5. Sidney J. Drumheller, Handbook of Curriculum Design for Individualizing Instruction, (Englewood Cliffs, New Jersey; Educational Technology Publications, 1971), pp. 9-10.

Identifying Guides to be Used in Planning, Directing, and Evaluating Instructional Activities

Objective 1 - Pretest

One or more of the following types of statements are commonly used in elementary science curriculum materials to guide the teacher's thinking when planning for instruction, during instruction, and during evaluation of the effectiveness of the instructional activities:

A. A science problem
B. A science question
C. A behavioral objective
D. A vague objective or an educational goal
E. A science concept, principle, or generalization
F. A means oriented statement that describes or refers to a student learning activity
G. A means oriented statement that describes or refers to a teacher responsibility or activity
H. (None of the above)

Demonstrate your ability to differentiate between the types of statements above by matching them with the following:

_____ 1. What are "G" forces?
_____ 2. Does heat make water evaporate faster?
_____ 3. Pupils should understand how good conservation practices help us to live better.
_____ 4. To review with the class the metric system of measurement.
_____ 5. To investigate the properties of magnets.
_____ 6. To explain to students how attraction and repulsion between charged objects are related to the kinds of electrical charges on the object.
_____ 7. To experiment to find out which of three liquids is the most viscous.
_____ 8. After instruction, given a hypothesis that can be tested, pupils should be able to design a laboratory procedure, or experiment, that will test the hypothesis.
_____ 9. Have the custodian explain to pupils how the heating system works.
_____10. To present to pupils information concerning reproduction in lower forms of animals.

____11. Students should be able to define peristalsis and describe its role in digestion and egestion.

____12. What keeps a man-made earth satellite in orbit?

____13. Electricity flows when there is a complete circuit.

____14. How are animals with backbones classified?

____15. This chapter is designed to acquaint pupils with the makeup of the earth's crust.

Identifying Guides to be Used in Planning, Directing, and Evaluating Instructional Activities

Objective 2 - Pretest

Title of accompanying manual: ______________________________

Locate in chapter or unit ________ of the accompanying teacher's manual the statements intended as guides to the teacher in planning, directing, and evaluating the effectiveness of instructional activities. In the spaces below, write each of the statements and list the page where found. To the left of each statement, indicate the type of statement by matching the statements with the types listed in the pretest for Objective 1.

Type of Statement		Statement	Located on Page
________	1.	______________________________ ______________________________	________
________	2.	______________________________ ______________________________	________
________	3.	______________________________ ______________________________	________
________	4.	______________________________ ______________________________	________
________	5.	______________________________ ______________________________	________
________	6.	______________________________ ______________________________	________
________	7.	______________________________ ______________________________	________
________	8.	______________________________ ______________________________	________

Identifying Guides to be Used in Planning, Directing, and Evaluating Instructional Activities

Objective 1 - Post-test

One or more of the following types of statements are commonly used in elementary science curriculum materials to guide the teacher's thinking when planning for instruction, during instruction, and during evaluation of the effectiveness of instructional activities:

A. A science problem
B. A science question
C. A behavioral objective
D. A vague objective or an educational goal
E. A science concept, principle, or generalization
F. A means oriented statement that describes or refers to a student learning activity
G. A means oriented statement that describes or refers to a teacher responsibility or activity
H. (None of the above)

Demonstrate your ability to differentiate between the types of statements above by matching them with the following:

_____ 1. Given causes of water pollution, students should be able to match them with related forms of prevention.
_____ 2. After instruction, students should be able to identify proper and improper uses of amphetamines and depressants.
_____ 3. Realize the necessity of a balanced diet.
_____ 4. In the natural state, the number of individuals in a species is reduced by a variety of mortality factors such as disease, starvation, and predation.
_____ 5. To help the pupils understand that structure is the basis for scientific classification and to introduce the pupils to the major animal groups.
_____ 6. What is the Milky Way?
_____ 7. Wind moves things.
_____ 8. To observe the effect of crickets on plant populations.
_____ 9. To use the phenomena of weather to lead the child to make observations, provide descriptions, originate questions and attempt to find answers.
_____10. Can iron filings be magnetized?
_____11. In which direction do roots grow?

____12. To motivate the pupils to want to learn more about the earth's appearance, make-up, and processes of change and to initiate a class project.

____13. Why should we cover our mouths when we cough?

____14. Variables must be identified and carefully controlled during an experiment in order to insure validity.

____15. To experiment and find out that fire needs oxygen.

Identifying Guides to be Used in Planning, Directing, and Evaluating Instructional Activities

Objective 2 - Post-test

Title of accompanying manual: ______________________________

Locate in chapter or unit ________ of the accompanying teacher's manual the statements intended as guides to the teacher in planning, directing, and evaluating the effectiveness of instructional activities. In the spaces below, write each of the statements and list the page where found. To the left of each statement, indicate the type of statement by matching the statements with the types listed in the post-test for Objective 1.

Type of Statement	Statement	Located on Page
________	______________________________ ______________________________	________
________	______________________________ ______________________________	________
________	______________________________ ______________________________	________
________	______________________________ ______________________________	________
________	______________________________ ______________________________	________
________	______________________________ ______________________________	________
________	______________________________ ______________________________	________

Curricular Components of the Instructional Approaches

This exercise was written primarily to enable the reader to:

1. Name the five major components of the instructional approaches to science education and describe the major function of each component.

2. Given a set of statements relating to the instructional approaches, name the component of the instructional approaches which each statement relates to.

Is instruction more like a good book or a clock? If you had a clock that did not perform its intended function, that is, keep accurate time, what would you do with it? Obviously, you would have it repaired or you would purchase a new one.

When a teacher's instruction does not perform its intended function, what should he do? Most of today's teachers do not know whether their instruction has performed its intended function or not. First, they are usually not sure of the function their instruction is supposed to fulfill. Second, when most of today's teachers who use an instructional approach give a test and their students do poorly, they are not accustomed to thinking of the low test scores as an indication of the quality of their instruction. Instead, many teachers tend to think the scores reflect a lack of student ability and interest, poor work habits, etc., and tend to blame the students for their poor showing.

Many teachers evidently do not stop to think that when they decided to provide certain instruction, they indicated the instruction was appropriate for the students in light of their ability, interests, and work habits. Low test scores then indicate the teacher was either wrong in assuming the instruction was appropriate for his pupils, or his instruction was of such low quality that his pupils did not learn much. In other words, if instruction is considered appropriate for a student, or group of students, and if the students do not learn, the instruction should either be "repaired" or replaced because it does not perform its intended function.

If you elect to use an instructional approach, or if your school furnishes you with curriculum materials (a support system) which require the use of an instructional approach, you should be concerned about the quality of the instruction which you provide your students. Does it work or doesn't it? Does it need "repairing" or replacing? How does one know whether his instruction is working or not? Let's examine the major components of instructional approaches and attempt to find an answer to this question in addition to providing you with information relating to the objectives for this section.

Components of the Instructional Approaches

Objectives. An instructional approach is to be used when the teacher is primarily concerned with teaching specified products and processes of science to children. If one is going to teach certain products and processes to children, it stands to reason he will be able to provide his pupils with more effective and efficient instruction if he knows which products and processes he is attempting to teach them.

There are a number of ways of labeling or specifying the products and processes with which one is primarily concerned. Among the ways are:

1. As science problems
2. As science questions
3. As behavioral objectives
4. As vague objectives
5. As science concepts, principles, and generalizations

It is believed by many persons that if one is interested in knowing when his pupils have learned, and whether or not his instruction has performed its intended function, the best way to specify what is to be taught is in the form of a behavioral objective. A behavioral objective is an explicit statement of what pupils are to learn or be able to do after instruction. Behavioral objectives describe the function of instruction. (A behavioral objective is not necessarily a good objective. It may be that sometimes a teacher's objectives are more in need of being "repaired" or replaced than his instruction.)

Preassessment. The second major component of instructional approaches is preassessment or pretesting. This is a test used to measure, prior to instruction, pupils' ability to perform the behavior described in the instructional objectives. A pretest is a test or measuring instrument to be used to determine which pupils actually need instruction relating to a particular objective.

Instruction. The third component of the instructional approaches is instruction. Let's assume we have stated as behavioral objectives a certain set of science products or processes that we want a group of children to learn. We give a pretest and none of the children do well on it. Therefore, all of the pupils need instruction; that is, they need whatever information and skills are believed by the teacher to be necessary to enable them to master the objective.

The means which teachers have at their disposal to bring information to students and to help students develop process skills are many: Books, films, television, tapes, pictures, charts, graphs, and other media. However, in elementary science, it is usually recommended that children get much of their information and learn process skills through the manipulation of objects such as rocks, balances, magnets, candles, animals, plants, etc. The type of materials used by the teacher during instruction depends partly upon the objective, and partly upon the skills of the teacher as well as upon the availability of materials and equipment.

The function of instruction is to bring about the learning desired by the teacher, or to enable pupils to master the teacher's instructional objectives. Instruction can take many forms: films may be shown, experiments and demonstrations may be conducted, field trips may be taken, books may be read, class discussions may be held, etc. If, after a reasonable amount of instruction, most students are unable to perform the behavior described in the objectives for which the instruction is intended, either the objectives are inappropriate for the pupils or the instruction has been ineffective and needs "repairing" or replacing.

Practice. The fourth component of instructional approaches is practice. Not all objectives lend themselves to practice. In instances where practice is appropriate, such as when pupils are learning to use a measuring instrument, ample opportunities for practice should be provided.

Practice exercises are similar to preassessment and postassessment instruments except for the purpose. While preassessment and postassessment instruments are used to determine how well the student can perform prior to and after instruction, practice exercises are used to enable the student to perform better. Practice exercises are not "graded," however, the student is provided with knowledge of results--whether he is right or wrong. Practice exercises are nonjudgmental. The preassessment or pretest is used in judging whether instruction is needed by a pupil for a particular objective and the postassessment is used in judging whether instruction has been effective. Practice exercises are not used in judging anything except possibly to determine whether or not the student is ready for the postassessment.

Postassessment. The fifth component of the instructional approaches is postassessment. Postassessment instruments, or posttests, are quite similar to preassessment instruments in that they call for the student to demonstrate his ability to perform the behavior described in the instructional objectives. Postassessment instruments are usually scored by the teacher. The results indicate to the teacher and pupil whether or not the instruction has been effective. If posttests show the instruction has not been effective; that is, many pupils score low, it should be changed ("repaired") until it does perform the function for which it is intended--enabling students to master the related instructional objectives.

In summary, the five major curricular components of instructional approaches are:

1. Instructional Objectives
2. Preassessment (pretests)
3. Instruction (which relates to specific objectives)
4. Practice (when called for)
5. Postassessment (post-tests)

To illustrate the use of the five components, let's use the following admittedly poor objective:

Objective: After instruction, students should be able to name the nine known planets in our solar system.

Preassessment. Ask pupils to name or list the nine known planets in our solar system.

Instruction. Pupils who did not name as many planets as the teacher is willing to accept as satisfactorily mastering the objective need information. In this case, they need the names of the planets they do not already know. They might read to learn the names, they might view a film or filmstrip, or they might gain the information some other way.

Practice. Committing to memory the names of the nine known planets in our solar system requires pupils to name or write the names a number of times, or pupils must engage in activities in which the names of the planets are used frequently.

Postassessment. Ask pupils to name or list the nine known planets in our solar system.

The above objective is a product-centered, low-cognitive, memory objective. Few teachers would, or should, require their pupils to master it. Let's choose another objective, one that is process-centered and examine the five components of instructional approaches.

Objective: After instruction, students should be able to measure an object and express its length and width to the nearest centimeter.

Preassessment. Provide pupils with a set of objects (books, boards, paper, etc.) and ask them to measure the length and/or width and express the measurements in centimeters.

Instruction. Pupils who do not already know how to measure in the metric system must be taught. The teacher can tell pupils about the markings on a meter stick and their names and explain they are primarily interested in centimeters at present. He can demonstrate how to hold the meter stick in relation to the object being measured and explain how to tell the number of centimeters long or wide an object is. (More than this may be needed, but it is an indication of the nature of instruction pupils need if they are to master the objective above.)

Practice. This objective also lends itself to practice. Pupils need, if mastery is desired, many opportunities to practice measuring objects and expressing the measurements in centimeters. They need to be provided with knowledge of results--whether they are right or wrong.

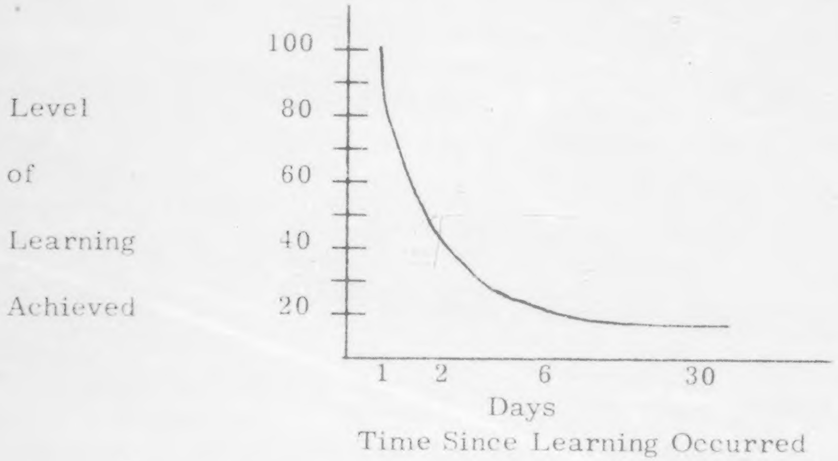
Postassessment. Provide pupils with a set of objects (may be the same as those used in preassessment) and ask them to express their length and width in centimeters.

Things to Think About. If we think of the instructional approaches as being used to enable students to master prespecified objectives, then we must consider the different learning rates of students. Since students do learn at different rates, it seems desirable that students be permitted to pace many of their learning activities in an independent learning setting when engaging in instruction that is aimed at bringing about student mastery.

It is not uncommon today to hear a teacher say, "I use an instructional approach, but I don't think it's necessary to teach for student mastery of specific objectives." It is not necessary, obviously, because most teachers today are doing precisely that--using their interpretation of an instructional approach but not teaching for student mastery. Most of these same teachers also give tests and many of their students fail or make "D's" because they did not master the things on the tests. While such teachers are saying they do not think it necessary, or desirable, to teach for mastery of prespecified objectives, they are giving their students low or failing grades because they have not mastered certain things. How can teachers who do not teach for mastery of specific objectives convince their failing students it is not necessary, or desirable, to teach for mastery?

Teaching for mastery raises a problem for teachers. If we assume mastery learning has occurred when students do as well or better on a test than we specify is necessary for mastery, have they truly mastered the objective? If they have, for how long?

It is ridiculous to speak of learning and mastery without considering forgetting. Research shows that as time passes, much of what is learned is forgotten. The forgetting curve looks something like this:



The curve indicates that "mastery" is a fleeting thing, unless opportunities for continued use of a concept or process are provided.

In teaching for mastery of the products and processes of science, one must consider things such as the capacity of the individual to learn, motivation, repetition, and retention. In deciding whether or not you use an instructional approach, do not overlook these factors.

Practice

Now that you have completed the instructional component of this exercise, here is some practice. (Notice that this practice exercise gives you practice in doing what the objectives for this exercise call for. This practice exercise is much like the postassessment, or post-test, for this exercise; because the post-test will also call for you to do the things specified in the objectives.)

Practice for Objective 1:

Number your paper from 1-5 and name the five major curricular components of the instructional approaches.

Briefly describe the major function or purpose of each component.

Practice for Objective 2:

Below are statements relating to instructional approaches. Number your paper from 1-10 and name the component which each statement relates to or concerns:

1. If someday during a lesson in which you are teaching science to children you ask yourself this question: "What is it that I really want these children to learn?" and you find you either haven't answered the question or are unable to answer it, it seems you have a minor problem that needs attention.

2. You have developed independent learning materials for a science unit. Five children have completed the materials for objectives one and two of the unit. Not one of the children scored higher than sixty per cent on the post-tests for the two objectives. Which component of your program is probably in need of "repair?"

3. You have pretest scores of all pupils on a set of objectives. Which curricular component will you use to gather information to be used along with pretest scores to determine whether or not your instruction has been effective; that is, whether or not it has performed its intended function?

4. You have specified the products and processes of science your pupils are to learn as behavioral objectives. Now, you must decide upon activities that will result in your students meeting your objectives in a reasonable amount of time. Which component must you now plan?

5. Your pupils' preassessment, or pretest, scores on a set of objectives indicate that the majority of them have already mastered most of the objectives at a satisfactory level. Which component of your program do you turn to next?

6. One of your objectives serves as an essential skill in an upcoming unit. Therefore, you require a high level of mastery. Which component of the instructional approaches has as its function the development of a high level of mastery?

7. You have a feeling that some of your students have already studied a topic you have selected for them. However, not one of them admits to having studied it before. Which component should help you to determine their current knowledge of your objectives relating to the topic?

8. Your independent learning materials direct students to do the following:

   a. Read pages 116-117 in the Red Book.
   b. Listen to cassette tape C-6.
   c. Obtain equipment box E-6. Use the equipment and follow the directions on the card in the box.

   Which component are your pupils engaging in?

9. Your approach calls for student pacing of learning activities. A student announces that he has checked his pretest for objective three and scored 92%. Which curricular component will the student be involved in next?

10. You have ordered some metersticks, graduated cylinders, metric weights, balances, etc., to be used in teaching your pupils the metric system of measurement. The materials have not arrived and you are almost ready to teach the measurement unit. Which component of your instructional approach is most affected?

Correct Responses:

Objective 1:

The name and major function or purpose of each component of instructional approaches are as follows:

1. Instructional objectives--describes in behavioral terms the specific products and processes of science that are to be taught to pupils.

2. Preassessment--used to determine the level of student achievement, prior to instruction, on each instructional objective, or used to identify students who do and who do not need additional instruction.

3. Instruction--purpose is to enable pupils to acquire the knowledge and process skills necessary for satisfactory performance on the instructional objectives.

4. Practice--to permit pupils to engage in the behavior described in the instructional objectives (if the objective lends itself to practice) so that a higher level of achievement is attained.

5. Postassessment--used to determine the level of student achievement after instruction on each instructional objective from which a judgment is made concerning the effectiveness of instruction.

Objective 2:

1. Your problem, if this occurs, concerns component one: instructional objectives.

2. Obviously, your *instruction* has been ineffective (assuming the objectives were appropriate for pupils); therefore, it is in need of "repair."

3. A comparison of post-test scores with pretest scores is the best indicator of the effectiveness of instruction; therefore, you will use the *postassessment* component to gather needed information.

4. Activities which result in students meeting instructional objectives compose the *instruction* component.

5. *You* turn to your next set or series of *instructional objectives* since pretest scores indicate pupils have already mastered the set of objectives you have been considering.

6. If you desire a very high level of mastery, you must provide pupils with *practice*.

7. If you wish to determine the level of student achievement on an objective prior to instruction, you use *preassessment* instruments or pretests.

8. Your pupils are engaging in learning or instructional activities. The component of the instructional approaches involved is obviously *instruction*.

9. *Preassessment.* Since the student has already mastered objective three--as indicated by his high pretest score of 92%--he will proceed to objective four and take the pretest for that objective.

10. You likely will not be able to administer pretests, provide instruction and practice, or administer posttests without the materials, but it is likely that your *instruction* will be most affected because the materials are definitely needed in instructional or learning activities.

Summary

Instructional approaches are used when the teacher wishes to bring about specific learnings in his students. The instructional objectives component of the instructional approaches is a description of the learnings desired by the teacher. Objectives should be appropriate for pupils in light of their stage of cognitive development, experiential background, ability, interest, etc. The preassessment component is used to determine whether or not a pupil needs additional instruction relating to an objective, or a set of objectives. The instruction component serves to bring about the learning described in the instructional objectives. If pupils do not learn and the objectives are appropriate for them, the instruction is likely inadequate and should be redesigned. The practice component serves to give pupils many opportunities to engage in the behavior called for in the instructional objectives--if the objectives lend themselves to practice. The postassessment component is used to determine whether or not the instruction has performed its intended function. Student scores on postassessment instruments are a reflection of the *quality* of a *teacher's* instruction--assuming the objectives are appropriate.

Teachers who use an instructional approach can improve their teaching, and the level of student achievement, by continually modifying and improving each component of their approach.

Components of the Instructional Approaches

Objective 1 - Pretest

In the spaces below, name and briefly describe the major function or purpose of each of the five main components of the instructional approaches:

1. ____

____

____

2. ____

____

____

3. ____

____

____

4. ____

____

____

5. ____

____

____

Components of the Instructional Approaches

Objective 2 - Pretest

In the space provided, indicate which component of the instructional approach each of the following statements relates to:

____________________ 1. Efforts by the teacher to help students achieve the instructional objectives.

____________________ 2. A description of a desired state of the learner following instruction.

____________________ 3. This component serves as the primary means of determining the effectiveness of instruction.

____________________ 4. A description of the specific products and processes of science to be learned.

____________________ 5. Used to determine whether or not instruction is needed by a pupil or pupils.

____________________ 6. Student manipulates real objects in order to gain information and acquire skills described in objectives.

____________________ 7. Activities with specific functions.

____________________ 8. Should be decided upon before learning activities are planned.

____________________ 9. A diagnostic measure.

____________________ 10. The more of this component, supposedly the higher the level of mastery, and the less likely forgetting will occur.

Components of the Instructional Approaches

Objective 1 - Post-test

In the spaces below, name and briefly describe the major function or purpose of each of the five main components of the instructional approaches:

1. ______________________________
____
____

2. ______________________________
____
____

3. ______________________________
____
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4. ______________________________
____
____

5. ______________________________
____
____

Components of the Instructional Approaches

Objective 2 - Post-test

In the space provided, indicate which component of the instructional approaches each of the following statements relates to:

____________________ 1. Used to find out whether or not the instruction should be repaired or replaced.

____________________ 2. Films, filmstrips, books, and other sources of information used by students.

____________________ 3. A description of the function instruction is to serve.

____________________ 4. Used to determine level of student achievement prior to his engaging in learning activities.

____________________ 5. The "heart" of an instructional program. The part that "gets the job done."

____________________ 6. If a high level of mastery is desired, this component may indicate remedial work or additional instruction is needed by some students.

____________________ 7. If a number of students "fail," this component has failed.

____________________ 8. This component describes what pupils will be asked to do to demonstrate their level of learning.

____________________ 9. Data gathered that is needed for comparison with data gathered later in order to determine whether or not the instruction has "worked" or has been effective.

____________________ 10. A number of opportunities for pupils to engage in a non-judgmental learning situation to enable them to do something better.

Developing Children's Potentials Using Experiential Approaches

This exercise was written primarily to enable the reader to be able to:

1. Given the name or description of two sets of objects, indicate which set could probably be used to provide children with the richer experience in science, or which set of objects would likely contribute more to the development of children's intellectual, language, social, and emotional potentials.

2. Given brief descriptions of two science activities, indicate which activity in each pair would likely contribute more to the development of children's intellectual, language, social, and emotional potentials.

Why Experiential Activities?

Let's assume you have been given a seedling and have been told that, with proper care, it will reach a height of thirty feet or more. What is meant by with proper care? In this case, it means such things as water, sunlight, and nutrients needed by the seedling. If these things are not supplied in the proper amount, the seedling will become stunted and will fail to reach its potential height of thirty feet or more.

Now, let's assume you have been given a small pig and have been told that, with proper care, it will weigh about 200 pounds in a few months. In this instance, proper care largely means a balanced diet. If a balanced diet is not provided, the pig will become stunted and will fail to reach its potential weight.

As a teacher you are not too concerned with growing seedlings and pigs. You are concerned with children. Given proper care, each child will grow and develop and will become the kind of person he has potentials of becoming. If proper care is not provided, he will become stunted or fail to develop his potentials. Are we, as teachers, in the business of "growing" people?

While some persons believe the major contribution of instruction in science to the lives of children is enabling them to store up and develop, and someday use, certain products and processes of science, other persons believe the major contribution of rich experiences in science to the lives of children is to enable them to develop their potentials. Such persons believe teachers are in the business of "growing" people.

Two such persons are Carl Rogers[1] and Arthur Combs. Combs stated, ". . . you and I are not the victims of the child's intelligence: we are in the business of creating it!"[2] (The same might be said for other areas in which children grow and develop.) Hein indicated that:

> What we know about how children learn tells us that they must have "stuff." It's not just nice to have these things, it's not just that it makes children happy to plan with pendulums and sand and gerbils, it is necessary that they do these things. It's not just that some of the discipline problems disappear when there are things in the classroom to occupy the children, but that intelligence will not develop fully unless children have the chance to test themselves against, and come to terms with, all sorts of chunks of the world of experience.[3]

The thinking among proponents of experiential approaches is that we will either provide experiences and stimulation to permit children's potentials to be developed, or we will fail to provide these things and the result will be persons who are not as bright as they might have been, persons who do not have the command of their language that they might have had, and persons who are socially and emotionally immature.

Experience is Important

In implementing the instructional approaches, the focus is upon specific instructional objectives (or science problems or questions, or science concepts and principles, etc.). We ask: "What knowledge (products of science) and skills (processes of science) do we hope pupils retain after the learning activity is completed?" In experiential approaches, we focus upon the activity in which pupils engage, and ask: "What kinds of experiences in science will contribute the most to the development of children's potentials?" Hein said it this way:

> . . . the stress is on the experience, not on what is learned. It is the experience of learning, of thinking something through, of testing it, observing it, and so on, that counts much more than what is learned.[4]

Objects and Activities

There is a great need to further conceptualize and describe the experiential approaches so the roles of the teacher and pupils are more clearly defined. We do know that one of the responsibilities of teachers is to *plan* for children to have *experiences in science*. One type of planning is when teachers make certain kinds of objects or materials available to pupils.

Question: What types of materials should the teacher provide?
Answer: Materials which will, hopefully, engage students in a rich or stimulating experience.

Let's consider various objects and materials from the standpoint of the probable richness of the experience they might make possible for children. Below are sets of objects and materials. Which set would likely provide the richer and more stimulating experience?

1A. A book without pictures.
1B. The same book illustrated with black and white pictures.

2A. A book with black and white pictures.
2B. The same book illustrated with color pictures.

3A. A book with color pictures.
3B. A 16mm color film with sound.

4A. A walnut.
4B. A walnut and a hammer.

Most persons would likely agree that the B objects in each set above would provide a richer and more stimulating experience than the A objects. It does appear, then, that we can make a judgment as to the probable richness of an experience based on the objects pupils are provided.

Let's consider some objects that are more "sciency." Which of these sets of objects would likely result in the richer experience?

5A. Flashlight battery, wire, and bulb.
5B. Flashlight battery, three wires, and two bulbs.

6A. Microscope and culture of a single microscopic organism.
6B. Microscope and cultures of three different types of microscopic organisms.

7A. Mealworm, sandpaper, cotton ball, soda straw, wax paper, string.
7B. Mealworm, sheet of $8\frac{1}{2}$ x 11 paper.

8A. Two pages in a book with colored pictures.
8B. Two corn seeds, two marigold seeds, two clover seeds, two pea seeds, two bean seeds, 1 set of labels, and germinating containers.

It seems that pupils given an opportunity to interact with and manipulate the materials in 5B, 6B, 7A, and 8B would likely have a richer, more valuable experience than pupils who might interact with the other sets of objects. Do you agree?

Another concern in conceptualizing and describing the experiential approaches is that of the nature of the activities. While it may be difficult to describe specific activities and indicate they are "models" of experiential activities, it seems it should be possible to indicate that one experience children may be provided is better than another. According to Raths, all other things being equal, one activity is more worthwhile than another if:

1. It permits children to make informed choices in carrying out the activity and to reflect on the consequences of their choices.

2. It assigns to students active roles in the learning situation rather than passive ones.

3. It asks students to engage in inquiry into ideas, applications of intellectual processes, or current problems, either personal or social.

4. It involves children with realia. (real objects)

5. Completion of the activity may be accomplished successfully at several different levels of ability.

6. It asks students to examine in a new setting an idea, an application of an intellectual process, or a current problem which has been studied previously.

7. It requires students to examine topics or issues that citizens in our society do not normally examine. . .

8. It involves students and the teacher in "risk" taking--not risk of life or limb, but a risk of success or failure. (Risk in that it may not turn out well rather than a risk of the student receiving a failing grade.)

9. It requires students to rewrite, rehearse, and polish their initial efforts.

10. It involves students in the application and mastery of meaningful rules, standards, or discipline.

11. It gives students a chance to share the planning, the carrying out of a plan, or the results of an activity with others.

12. It is relevant to the expressed purposes of the students. (That is, it is related to their interests and they will feel a personal involvement in the activity.)[5]

With the exception of statements seven, nine, and ten above, these statements can serve as clues to teachers in evaluating the worth of experiential activities. (Statement seven seems to relate to things not generally considered to be a part of elementary science, and statements nine and ten are oriented more toward the instructional approaches than toward the experiential approaches.)

Below are some activities. Which would likely be more valuable for pupils to engage in? (Number your paper from 1-5 and indicate which of each pair is probably the richer, or would likely contribute more to the development of children's potentials.)

1A. Children search for seeds in various fresh fruits. They observe the location of the seeds within the fruits and compare their structure. Finally, the children record the number of seeds they find in each complete fruit.

B. Children view a filmstrip titled: "Seeds: Where They Come From."

2A. Children work with tangrams--a geometric puzzle consisting of a square divided into seven geometric shapes with which a great number of geometric and pictorial arrangements can be made. (Many tangram problems are manageable for preschool children and some are challenging to most adults.)

B. Children are given a ditto sheet containing a number of angles. Each child is to use a protractor to measure the angles and record the measurements in the proper space on the ditto sheet.

3A. Pairs of children are given a plastic container containing two guppies, small plants, and a few snails. The children are to name all of the visible populations, and are to rank them in order from most number of members to least number of members.

B. A class of pupils are instructed to read "the section on plants." When it appears to the teacher that most pupils have read the material, a "discussion" is held.

4A. A child is given a box containing the bones of some animal and is at work assembling a skeleton.

B. Students construct a complete circuit by following specific verbal directions of the teacher: first do this . . . second, do that . . ., etc.

5A. Children are given an electric circuit board with hidden wires and a battery and bulb and are trying to determine the wiring pattern of their board.

B. The teacher asks all pupils to watch as she demonstrates how to identify the wiring pattern in a circuit board with hidden wires.

Children who engage in the "A" activities will likely have a richer or more valuable experience than children who engage in the "B" activities.

Keep in mind that, in providing experiences in science that are designed to help develop children's potentials, the products of science are used and the processes of science are used, but upon completion of the activities pupils are not evaluated and "graded" on their ability to remember the products or to use the processes. For example, in 4A above, the process of observation would certainly be used by the child as he assembles the skeleton. The same is true in other situations, such as in 5A--there would be little or no point in asking students to remember the way their board is wired.

Initiating and Directing Experiential Activities

This exercise has dealt mainly with the probable richness of the experiences certain sets of science materials and certain activities might afford pupils. It is common for some persons in learning about experiential activities to come to the conclusion that all such activities are pupil initiated and pupil directed--in a "free play" type setting. Certainly, pupils can and should initiate and direct many of their own experiential activities, but it was pointed out above that one of the responsibilities of the teacher in experiential approaches is to plan interesting and stimulating experiences for his pupils. Many of these experiences might be large group activities.

Regardless of whether the teacher or pupils initiate and direct experiential activities, it is the teacher's responsibility to provide the objects, materials, and equipment which permit or make possible rich experiences in science--when the development of children's potentials is the major goal of the science program.

References and Sources of Additional Information:

1. Carl R. Rogers, "Can Schools Grow Persons?" Educational Leadership, 29 (Dec., 1971), 215-217.

2. Arthur W. Combs, "New Concepts of Human Potentials: New Challenge for Teachers," Childhood Education, 47 (April, 1971), 349-355.

3. George E. Hein, "Piaget, Materials, and Open Education," EDC News, (Winter, 1973), 6.

4. Ibid.

5. James D. Raths, "Teaching Without Specific Objectives," Educational Leadership, 28, (April, 1971), 714-720.

Developing Children's Potentials Using the Experiential Approaches

Objective 1 - Pretest

Indicate which set of objects in each pair below could probably be used to provide children with the richest experience in science, or which set of objects could likely be used to contribute more to the development of children's intellectual, language, social, and emotional potentials. (Circle the number of your choice.)

1A. Eight buttons or crayons or bottlecaps or similar objects in a tray
B. Powdered sugar, chalk dust, iron filings, sand, toothpick, magnet

2A. Kool-aid, water, sugar
B. Cooking oil, vinegar, alcohol, blotting paper, droppers, wax paper

3A. Two pages in science textbook with colorful pictures and suggested questions for teacher to ask pupils
B. Funnel, filter paper, and materials to be filtered

4A. Three sheets of newspaper, piece of wood about size of ruler and about three feet long, hammer, table
B. Two guinea pigs, cage, exercise material, maze, copies of maze pattern, sixty-second interval timer

5A. Large picture showing cloud types
B. Packet of salt, tea bag, tumblers of water, magnifier

6A. Uncooked spaghetti, thread, yarn, scraps of cloth, wire, sugar cubes, styrofoam blocks, aluminum foil
B. Meter stick, overhead projector with transparencies, index cards

7A. Spool, rubber band, two match sticks, pieces of soap
B. Two pages in science textbook with colorful pictures

8A. Dry cells and holder, insulated wire, bulbs, switches, and small electric motors
B. Thread, yardstick, pencil, several books, two paper bags of equal size and weight, candle, matches

9A. Large chart showing basic types of foods
B. Sandpaper, two wood blocks, toy car, board about 6' long, soap or wax

10A. Brick, small rubber balloon, soda straw
B. Two pulleys, rope, pail, objects of varying weight

Developing Children's Potentials Using the Experiential Approaches

Objective 2 - Pretest

Indicate which experience in each pair described below would likely contribute the most toward the development of children's potentials. (Circle the letter of your choice.)

1A. Children warm and cool Freon in small plastic bags causing it to evaporate (when warmed) and condense (when cooled).
B. Each child prepares a written report, taken from the encyclopedia, on weather.

2A. Children are learning how sound is produced by observing as a classmate strikes a tuning fork against a book.
B. Children have been given small blocks of wood, nails, and rubber bands and are making different "sound generators."

3A. A child has a balance board (a balanced strip of pegboard), supply of washers of different weights, and paper clips and is "messing around."
B. A child is following the directions in his independent learning materials and is finding the A. M. A. (actual mechanical advantage) of levers by dividing given resistances or weights by effort.

4A. A child has a saucer, a container of water, a dropper, different powders (cornstarch and flour), and different liquids (detergent, oil, syrup), and is dropping and adding these materials to saucers of water.
B. A child is learning about surface tension by viewing a filmstrip and reading the captions.

5A. A child is using a formula and converting Fahrenheit readings to Celsius readings.
B. A child is mixing two equal amounts of water of different temperature to develop a graph that will enable him to predict the temperature of two equal amounts of water whose temperature is unknown.

6A. Children are placing leaves on wet soil to see if the leaves help keep the soil damp.
B. Children have three containers of wet soil. They place leaves on top of one, plastic over the other, and nothing over the third. Later they will examine them for wetness.

7A. Children are dissolving sugar in water and finding whether or not stirring affects the time it takes a certain amount of sugar to dissolve.

B. Children are finding the difference between the time it takes certain amounts of salt and sugar to dissolve when stirred and unstirred.

8A. Children are observing the teacher exert pressure on the ends of a bar of soap that has been sliced at an angle to "demonstrate" how block mountains are formed.

B. Two children are disassembling a 1.5 volt electric motor that has stopped operating. Next, they will try to reassemble it, hoping it will work properly.

9A. A child is reading an assignment in his science textbook after being told by his teacher to "Read the next two pages and we will discuss it when you finish."

B. A child is "daydreaming" after observing a picture in his text near where he is supposed to be reading (his "daydream" involves the ideas in the picture).

10A. A child is describing as many ways as he can to show a classmate that air expands when heated.

B. A child who has not been pretested and who already knows that air expands when heated is watching a demonstration that shows that air expands when heated.

Developing Children's Potentials Using the Experiential Approaches

Objective 1 - Post-test

Indicate which set of objects in each pair below could probably be used to provide children with the richer experience in science, or which set of objects could likely be used to contribute more to the development of children's intellectual, language, social, and emotional potentials. (Circle the number of your choice.)

1A. Crayons, paraffin, three birthday candles of different colors, matches (with proper precautions), and a large piece of heavy cardboard.
B. One-fourth grapefruit, orange, or lemon.

2A. Large chart from United States Steel showing raw materials from which steel is made and how it is made.
B. Baking soda, vinegar, Alka Seltzer tablet, alcohol, tumblers, and water.

3A. A "magnet kit" with specific recipe-type instructions telling what should be done at each step.
B. A number of different types of magnets and other materials--metal and non-metal--and a card reading: "What can you find out?"

4A. Water, dropper, small vial of motor oil, small amounts of six different household detergents, plastic tumblers.
B. Two pages in a science textbook with colored pictures.

5A. A carrot, a piece of the stem of ivy, two glasses and water.
B. A jar with a lid, a spider, twig, and several small insects.

6A. Two balloons and a yardstick.
B. Two balloons, water, and plaster of paris.

7A. Plastic wading pool containing 12 crayfish, gravel, water, clear plastic containers with covers (big enough to hold a crayfish), food for crayfish, objects in pool for crayfish to hide under.
B. Filmstrip titled "Crayfish."

8A. Section in new science textbook titled "How Can Light be Reflected?"
B. Mirror Cards (ESS unit composed of a box containing twenty-one different sets of cards printed with colorful pictures or patterns. Activities involve trying to match the picture on one card to the picture on another card by using a mirror to reflect some part or all of the picture).

9A. Plastic vials, syringe pumps, plastic tubing, and water.
B. Flashlight, globe, rubber ball, and string.

10A. A microscope, dropper, glass slides and cover slips, and an aquarium.
B. A section in a new science textbook with colorful pictures titled "Cells Divide."

Developing Children's Potentials Using the Experiential Approaches

Objective 2 - Post-test

Indicate which experience in each pair described below would likely contribute more toward the development of children's potentials. (Circle your choice.)

1A. Children are hatching brine shrimp and then feeding them to tropical fish.
B. Children sit in their seats in nice straight rows while the teacher attempts to explain photosynthesis.

2A. Children read a section in their text titled "Matter Expands" and then they "discuss" it; that is, the teacher asks pupils questions about what they have supposedly read.
B. Children are having an ice cube melting race; that is, they are seeing who can melt an ice cube the quickest.

3A. First grade children are sorting buttons by size, shape, color, and other properties they select or the teacher specifies.
B. First grade children are building with geo blocks (a large box of unfinished hardwood cut into a wide variety of shapes and sizes. The smallest is a half-inch cube; the largest is a 2" x 2" x 4" oblong).

4A. Pairs of pupils have been given two tumblers, one with water and the other one empty, and a piece of plastic tubing and have been told to try to transfer the water from one container to another without lifting and pouring from one container to another.
B. Children are reading a "comic book" produced by the Central Beverage Association in which the "hero" saves the day after drinking a certain drink.

5A. Children are divided into groups of five and are heating glass containers capped with balloons in order to learn that air expands when heated.
B. Children have learned that when a candle burns in a container inverted in water that water rises in the container shortly after the candle goes out. They are working in groups of five attempting to identify other things that interact with the air in an inverted container that causes water to rise in the container.

6A. Tim is listening to a cassette tape explaining food webs--the relationships that exist among plants, plant eaters, and animal eaters.

B. Jill is attempting to construct a food web chart showing the relationships that exist between the class frog and certain insects and plants.

7A. Other pupils in the class observe as two pupils demonstrate from the front of the room a concept or principle.

B. Children collect samples of stagnant water from different locations near their school. The samples will later be examined under a microscope. (Consider the collecting experience only.)

8A. Pupils are viewing a filmstrip that shows views in space as seen through a powerful telescope.

B. Pupils are taking a post-test during which they are being asked to demonstrate their level of learning on three objectives from a unit titled "The Universe."

9A. Marvin is working with independent learning materials which direct him to follow specific instructions in the manipulation of a set of washers (used as weights) and an equal arm balance.

B. Julie is working at the science interest center with an equal arm balance and with a wide variety of other materials that she has decided to include in her activity.

10A. Students are working with five "mystery powders" and are trying to identify them using a variety of tests--some suggested by the teacher and some thought up by the pupils.

B. Students are learning about suction by observing the teacher place two sink plungers against a table top. Pupils attempt to pull the plungers from the table.

Types of Science Activities

This exercise was written primarily to enable the reader to be able to:

1. Given statements relating to activities initiated and directed by the teacher (or by independent learning materials), match the statements with the following:
   - A. An activity that could best be described as an experiment (conducted either by the teacher or by pupils).
   - B. An activity that could best be described as a demonstration (conducted either by the teacher or by pupils).
   - C. An activity conducted by the teacher mainly for motivational purposes.
   - D. An activity, other than type B or F, in which pupils are primarily observers (usually under natural conditions).
   - E. An activity which proceeds step by step or in recipe fashion--as a result of the teacher or pupil following specific directions.
   - F. Other: An activity centering around the use of books, films, filmstrips, records, tapes, pictures, television, lecture-discussion, but not involving the use of science materials by the teacher or pupils.
2. Given statements relating to the following types of activities, indicate which type is referred to or described in each statement:
   - A. Activities initiated by the teacher but directed by the pupil.
   - B. Activities initiated and directed by the pupil.

Student Involvement in Science

The plea that children be allowed to learn by manipulating objects is probably heard more frequently in science than in any other area. The cry is stated in many ways: Science should be activity centered, let pupils manipulate the materials, pupils should solve problems, engage pupils in inquiry, let pupils discover, involve pupils in science, science is a verb not a noun, etc.

Karplus and Thier indicated there are four degrees of student involvement in science. They are:

1. Children read about science.
2. Children participate in a classroom discussion about science readings.
3. Children observe a demonstration in which objects are used to illustrate some natural phenomena.
4. Children observe and manipulate objects which they choose or which the teacher has chosen.[1]

The above "degrees of involvement" are quite similar to Ipsen's "almost distinct activities." He described four types of activities in science and indicated each type makes significantly different demands on the teacher, children, and materials. The types of activities, according to Ipsen, are:

1. Study. (The objects of study as the term was used are books.) (Compare this type of activity with Karplus and Thier's lowest level of involvement above.)
2. Observation. (Compare this type of activity with Karplus and Thier's third level of involvement above.)
3. Experimentation. (The child manipulates the observed objects. Some experiments might be carefully structured, but according to Ipsen, more useful would be freer experiments in which the child actually seeks new (to the child) facts of science. Note Karplus and Thier's fourth level of involvement above.)
4. Development. In connection with this type of activity Ipsen stated:

> The bigger ideas of science--whether concepts or facts--must be developed slowly and carefully. They require a teacher involvement that is likely to be much greater than in any of the preceding activities. To develop the meaning of a concept such as force or to establish the reasonableness of a fact such as Newton's Third Law of Motion, a lot of classroom discussion, demonstration,

> and experimentation seems almost essential. Books may certainly help, and observation and experimentation may provide useful background. But in the end, demonstrating and discussion must do much of the job of developing the more unfamiliar concepts and the more complex facts.[2] (Which of Karplus and Thier's levels of involvement are related to Ipsen's development activity?)

As you can see from the above, it is possible to group or categorize science activities in different ways. It is also obvious from the above that there is not agreement among authorities in science education as to what constitutes the most desirable types of science activities. Neither is there agreement concerning the meaning of terms relating to various types of activities. For example, the terms experiment and demonstration are sometimes used synonymously by some persons while others object strongly to such use of the terms. Some persons use experiment to refer to almost any activity in science. Attempts to bring order to the chaotic situation that exists is likely to be viewed by some persons as simply compounding the situation. So be it . . .

Initiating and Directing Science Activities

Students do something. They manipulate equipment, they watch films, they read, they discuss, they observe, etc. In other words, they do engage in activities. Perhaps we can get agreement on at least the following concerning activities in elementary school science:

A. Most science activities are initiated or begun in one of the following ways:

   1. By the teacher--pupils commence some activities because they are directed to do so by the teacher.

   2. By independent study guides--materials which permit students to pace their own learning activities contain directions to pupils to commence certain activities.

   3. By the pupil--pupils may commence activities because they choose to do so.

B. Most science activities are directed by one of the following:

1. By the teacher--once an activity is begun, it proceeds in the direction the teacher wants it to go.

2. By independent study guides--materials which permit pupils to pace their own learning activities contain prescriptions of what students are to do.

3. By the pupil--the direction in which an activity unfolds or develops is determined by student interest.

It appears then that some activities may be teacher initiated and teacher directed, some activities may be teacher initiated and pupil directed, and some may be pupil initiated and pupil directed. And, some activities are initiated and directed through the use of independent learning materials. (Some activities may be pupil initiated and teacher directed, but this is not too likely.)

Activities Initiated and Directed by the Teacher or by Independent Study Guides

Most activities that are initiated by the teacher, and that proceed in the direction the teacher wants them to go, and most activities initiated and directed through the use of independent study guides can be labeled experiment, demonstration, motivational, observation under natural conditions, step by step or recipe, and other activities which center around books, television, films, tapes, records, and similar materials. (It is suggested that you review objective one for this exercise at this time.)

Experiments. It is generally agreed that an experiment is conducted in order to solve a problem--or more accurately to gather data which is used in solving a problem. Therefore, an experiment is usually a teacher-initiated and teacher-directed instructional activity that yields information. An experiment is called for when information is needed that is not available in books or other sources. (However, a teacher might have pupils obtain needed information through experimentation even though it is available in books because he wants his pupils to practice or use certain processes of science while obtaining the information.)

Traditionally, teacher initiated and directed experiments were supposedly used to develop pupils' problem-solving (process) skills and to teach the products of science concurrently. For example, "problems" such as these were recommended:

1. How do the poles of a magnet affect each other?
2. Do plants need water in order to grow?
3. What happens to a bimetallic strip when it is heated?

Today, some persons feel there are problems which are of more interest to pupils than traditional product-centered problems such as those above. Some "problems" that today's elementary pupils might solve are:

1. Do mealworms prefer Wheaties or Cheerios?
2. What happens when an Alka-Seltzer tablet is placed in a vial of cooking oil?
3. How much water can a paper towel absorb?

Experimentation has not played a significant role in elementary science education. There are a number of reasons why elementary teachers have not used experiments widely. Among the reasons are:

1. One experiments when he needs information ordinarily not otherwise available. Most elementary teachers and pupils seldom need information they cannot obtain by other means.

2. There has been a shortage of suitable problems which lend themselves to experimentation by elementary teachers and children.

3. Many teachers have not been trained to recognize or pose problem situations which lend themselves to experimentation.

4. Many teachers have not been trained to conduct experiments so they can do so with confidence.

5. There has been, and still is, a shortage of equipment and materials in many schools.

Many teachers think there are certain ways to conduct an experiment or certain steps to be followed. In focusing upon "how to conduct an experiment" or "the steps to follow in experimenting," one might lose sight of the real purpose of the experiment.

Let's forget about how an experiment should be conducted and think instead about the kind of information that is needed in solving the problem at hand. Consider this problem: "Do some substances conduct heat faster than others?" It seems one needs to know the rate at which different substances conduct heat. If a number of substances are tested and all seem to conduct heat at about the same rate, one would tend to conclude that some substances do not conduct heat faster than others. If the rate of heat conduction of different substances differs, he would tend to conclude that some substances do conduct heat faster than others. The problem really becomes: How can we determine the rate at which certain substances conduct heat? If we can find the rates at which substances conduct heat, we can compare the rates (the data we collected) and solve the original problem: "Do some substances conduct heat faster than others?"

If you had an aluminum rod 20 centimeters long and 3 millimeters in diameter, how would you determine the rate at which it conducts heat? If you can answer correctly, you would likely be able to gather data to be used in solving the original problem: "Do some substances conduct heat faster than others?"

Demonstrations. Let's assume a student is about to commence work on a series of independent, student-paced activities which require him to use an equal-arm balance. The balance is disassembled and the student does not know how to assemble it. Neither do other students who will be working on the same exercise a few days or weeks from now. Doesn't it make sense for the teacher to initiate and direct an instructional activity to demonstrate how to assemble the balance so all pupils will be able to proceed independently with the activities when they get to them? One purpose of a demonstration is to enable pupils to be able to assemble and use science equipment. Other things of this nature that might be demonstrated in teacher-initiated and teacher-directed activities are these:

How to prepare a slide for viewing under a microscope.
How to anchor a candle so it won't fall over.
How to strike a match away from the body rather than toward it.
How to hold a thermometer at eye level to get a more accurate reading.
How to remove insulation from wires.

You might be thinking at this time--"Yes, but these things aren't really teaching science." There are other purposes of and ways of using demonstrations that are more associated with "teaching science." One of these ways might be thought of as a "show and tell" activity. For example, the teacher might *show* pupils that a metal ball passes through a metal ring with ease before the bell is heated; and after heating, the ball does not pass through the ring. *After* the activity (the passing of the ball through the ring before and after heating) the teacher *tells* pupils that metals expand when heated and this accounts for the ball not passing through the ring after it was heated.

Another type of demonstration might be thought of as a "tell and show" activity. The teacher might *tell* students that metals expand when heated. He then proceeds to *demonstrate* (or *show*) the principle by passing a ball through a ring, then heating the ball, and *showing* that it will not pass through the ring after it is heated.

"Show and tell" and "tell and show" demonstrations are used to show or clarify products of science such as these:

Magnets are surrounded by lines of force.
Substances in a mixture can be separated.
The volume of a liquid is conserved (stays the same) regardless of the shape of the container.
Air expands when heated.
Water expands when it freezes.
Sound is caused by vibration.
Like electrical charges repel and unlike charges attract.

Demonstrations usually do not take a great deal of time if advance preparations have been made and if all goes well. Sometimes things do not go well and the demonstration "fails." Failure usually means things did not work out the way the teacher *told* the pupils it would or the way he expected. When this happens, the insecure teacher is likely to feel embarrassed and inadequate in science, (and telling teachers that they should be glad when demonstrations fail because then they have a *real* problem for pupils to solve usually does not help to relieve their feelings).

What is the difference between a demonstration and an experiment? Beginning teachers usually reply that if the teacher manipulates the equipment it is a demonstration, and if pupils manipulate the equipment it is an experiment. Not so. The difference lies in the *purpose* of the activity. If a teacher wishes to *demonstrate or show* that air expands when heated, the activity is a demonstration. If the teacher wants to guide pupils as they try to solve a problem--such as: "Does air expand when it is heated?" the activity is usually considered an "experiment." The way the materials are manipulated in both instances will be much the same regardless of who manipulates them. (Reference 3, which contains a much more complete discussion of experiments and demonstrations, should be made available to uses of this exercise.)

Motivational Activities. Sometimes we see teachers commence a lesson or study of a unit by conducting an activity with little explanation or comment before or during the activity. After the activity, the teacher might ask students to try to explain what happened and why it happened.

This type of activity may be used to get pupils interested in a topic or lesson, or upcoming activity, or to motivate them. Therefore, let's refer to such activities as motivational. Motivational activities may precede both teacher-initiated instructional and experiential activities.

Observation. Many teacher initiated and directed instructional and experiential activities in science are largely "looking" activities. When children visit a zoo, a forested area, etc., most of the activities are observational in nature. They are primarily there to see what they can see. Usually, what they are there to see is related to a unit of study under way in the classroom.

Many children delight in observing fish in an aquarium, small animals in their cages, mealworms as they crawl about objects placed in their path, etc. A trip to a planetarium is largely observational in nature. If a resource person is invited in to show pupils his collection of rocks, pupils largely observe (and listen). Actually, most demonstrations are also observation type activities.

Step-by-step or Recipe Activities. Experiments are centered around science problems. Most demonstrations are centered around science facts or principles and the use of certain pieces of equipment. Observational activities center around the objects and materials (animals, rocks, trees, flowers, etc.) being observed. If the children are separated from the objects and materials, observation stops.

There are other teacher initiated and directed activities, which I have labeled step-by-step or recipe-type activities that are centered around detailed instructions in the teacher's guide or instructions to pupils in independent study materials. That is, children do certain things seemingly for no reason other than because they are instructed to do so by the teacher or by independent learning materials. In these activities children do as they are instructed--they have little or no idea as to how what they are doing fits with what comes next. In fact, they usually do not have any idea as to what they will do next.

I have observed some teachers carrying out explicit directions in their teacher's guide and it was evident that they were not sure what came next or how what they were telling the pupils to do fit into the overall activity described in the guide. For example, in a Science-A Process Approach lesson in which pupils are to identify variables that might affect the time a round object takes to roll down an inclined plane, the activity proceeds step by step guided by the teacher who follows the "recipe" in the guide. First, an inclined plane is set up and children are shown some cylinders. Second, the teacher is instructed to ask the children to describe the similarities and differences in the cylinders. Third, the teacher is to ask, "Which cylinder will roll down the board in the shortest time?" Next the teacher is directed to select a child to put the cylinders in position at the top of the incline and to release them simultaneously. What should be done next? Certainly the pupils do not know. And, neither do some teachers until they read their guide. Therefore, it seems the main reason pupils engage in activities of this type is because they are instructed to do so by their teachers who were instructed to tell their pupils to do so by persons who wrote the guides.

In another Science-A Process Approach lesson, the section of the recipe-type instructions reads:

> Give each pair of children two sheets of plain white paper, a meterstick, and the clamp for attaching the viewing tube to the meterstick. Demonstrate how to locate the pinhole at the view end of the sighting tube at a specific location on the meterstick. Then have all the children adjust their viewing tubes so that the pinhole is at the 20-centimeter mark.
>
> Have one partner hold the meterstick in a steady vertical position directly over the piece of plain paper. The other child should then draw the outline of the square hole on the paper, as he sees it through the pinhole. He can do this most easily if he puts dots at the four corners as he looks through the tube, and

> then later sketches the square by drawing line segments. He should write "20cm" inside the square to indicate that this was the size when the distance of the pinhole was 20 centimeters from the paper. The children should then have a chance to sketch the square on their papers.[4]

What should the teacher direct the pupils to do next? Since you do not have the guide--the "recipe" to follow--you would be unable to continue the lesson.

Other Teacher Initiated and Directed Activities. Many *instructional* and *experiential* teacher initiated and directed activities in science center around things that are not usually called science equipment: books, tapes, records, films, filmstrips, television, etc. Teachers have been accused of abusing rather than using some of these materials. This implies there are "correct" ways to use such materials and ways of using them that are considered incorrect. These materials are usually used in instructional approaches in teaching the products of science to children.

Teacher-Initiated and Pupil-Directed Activities

If you have ever tried to direct a large group science lesson and gave pupils some interesting materials before giving them instructions, you probably had trouble getting their attention. They were more interested in "playing around" with the objects than they were in listening to your comments. This is an indication that pupils sometimes think of things to do with science materials that are more interesting to them than the things the teacher has planned for them to do.

Let's say a teacher initiates a large group experiential activity by giving his pupils a mealworm, a soda straw, a cotton ball, a small square of sandpaper, a small piece of masking tape, a piece of aluminum foil, and a piece of wax paper. Will most children sit and wait until the teacher directs them to engage in a particular activity? No, most of them will think of many activities (the "I wonder what the mealworm will do if . . ." variety) to engage in. It won't be long until the room is buzzing with excitement, sharing, and *science*. Or, is it science????

Most teacher-initiated and pupil-directed activities are experiential in nature. The teacher sets the stage for "exploration" and "discovery" by providing pupils with materials which lend themselves to pupil-directed activities. The teacher is a guide and resource person, a helping hand when needed, and is in control of the situation. However, the direction in which the activities proceed (in large group settings not all pupils will do the same thing with the materials) is determined largely by the pupils. It seems Elementary Science Study personnel had teacher-initiated and pupil-directed activities in mind when they stated:

> In the old days, elementary school children learned science by reading books, reading about experiments, discussing what they read, and watching the teacher do experiments. Doing an experiment was like following a recipe in a cookbook where one looked for the results described. The teacher ran the whole "show." She showed the children what to do, told them what to look for, and summarized what they observed. The teacher or the book was the ultimate source of information for answering any question. The children were told what the teacher wanted them to know and were evaluated on their ability to parrot back these facts. What is teaching all about? The teacher is a person who:
>
> 1. is not too busy to listen to your ideas.
> 2. helps you find exciting things to do, and then lets you do them.
> 3. helps keep others from bothering you when you want to think.
> 4. gets excited with you about your ideas and your discoveries.
> 5. helps you think of questions that excite you to think about.
> 6. encourages you to work on different problems, without ruining it by telling you his answers all the time.
> 7. is a helper when you need an extra pair of hands and all others are busy.
> 8. helps you realize what you've learned.[5]

Pupil-Initiated and Pupil-Directed Activities

The activity described above involving mealworms was a large group activity in which all pupils were working with the same materials but doing different things with them. It is possible to have much the same kind of situation but with pupils working with different materials.

Let's assume a number of boxes of science "stuff," such as those mentioned above, and magnets, compasses, microscopes, pendulums, even filmstrips, books, etc., are available in the classroom. If these things are available, will children want to interact with them? Most children will. I know of one teacher who uses time with materials such as these as a reward for some pupils who have completed teacher-prescribed activities in other subject areas.

When interesting materials are available, and pupils are free to initiate and direct their own activities (with teacher guidance), it may not be necessary that a special time be scheduled for science--although it might be as indicated by Thier who stated:

> An outstanding attribute of the study of science is the opportunity it provides for encouraging projects and related activities on the part of individual pupils. In addition, the strong interest in doing a project shown by many elementary school children makes the encouragement of pupil projects a desirable part of any science program. Usually, projects evolve as a result of one or more students' strong interest in some aspect of the topic being studied or as a result of a pupil's desire to explore an event or topic even totally unrelated to the work in the class. The degree to which pupils engage in individual projects will be determined to a large extent by your attitude in the classroom. If, when immediately unanswerable or unrelated questions come up, you encourage and perhaps guide individuals to do their own investigating of problems. This procedure will become a usual form of activity in your classroom. One way to encourage individual projects is to make equipment and materials easily available to students.[6]

As you see, Thier believes that most pupil initiated and directed activities (but encouraged by the teacher) should largely grow out of large group teacher initiated and directed activities.

Summary

There are many different types of activities conducted by teachers and pupils in elementary school science. Although many different terms are used to name the activities, almost all can be classified as one of the following types:

1. Teacher initiated and teacher directed.
2. Teacher initiated and pupil directed.
3. Pupil initiated and pupil directed.
4. Initiated and directed by independent study guides.

If a teacher wishes to teach certain products and processes of science to his pupils, he will likely find that teacher-initiated and teacher-directed activities, and activities initiated and directed by independent learning guides, will best serve his purposes. If a teacher believes that children should be provided with interesting and stimulating experiences in science, he will likely find that some teacher-initiated and teacher-directed activities, many teacher-initiated and student-directed activities, and many pupil-initiated and pupil-directed activities can be used to serve his purposes.

What evidence do we have that indicates teacher-initiated and teacher-directed activities in elementary school science are more or less valuable than activities initiated and directed by pupils?

Practice and Self-Check

This exercise has dealt with science activities in terms of whether they were initiated and directed by the teacher, or by independent study guides, or by pupils. Below are some statements about teacher initiated and directed science activities. Number your paper to ten and match the statements with the following: (The correct responses are at the end of the next practice exercise.)

A. An activity that could best be described as an experiment (conducted either by the teacher or by pupils).
B. An activity that could best be described as a demonstration (conducted either by the teacher or by pupils).
C. An activity conducted by the teacher mainly for motivational purposes.

D. An activity, other than type B or F, in which pupils are primarily observers--usually under natural conditions.
E. An activity which proceeds step by step or in recipe fashion--as a result of the teacher or pupil following specific directions.
F. Other: An activity centering around the use of books, films, filmstrips, records, tapes, pictures, television, lecture-discussion, etc., but not involving the use of science materials by the teacher or pupils.

1. Children are working in pairs. There is a slight pause as the teacher checks her guide for further directions to give her pupils.

2. The teacher tells pupils, prior to conducting an activity, to notice certain things as he conducts the activity.

3. Children engaging in this activity may have to keep notes so they won't forget the information collected.

4. Students are usually told in advance what will happen and what to watch for.

5. All children in the class are watching baby guppies.

6. A student's workbook reads: "Hold the bag to your face. Look into the bag. Is there light in the bag?"

7. Used in solving a problem.

8. Students are mainly passive receivers of information.

9. Used to make students wonder about and become interested in a certain phenomena or topic.

10. If this activity does not go as the teacher said it would, it has "failed."

Below are statements relating to activities that are less structured than those above. Match the statements with the following: (The correct responses are in the last paragraph of this exercise.)

A. Activity initiated by the teacher but directed by pupils.
B. Activity initiated and directed by the pupil.

1. May be engaged in by pupils in their "spare time."
2. All pupils have the same materials but are doing different things with them.
3. Pupils who are working in science are working on different projects. Not all pupils are working in science.
4. Materials must be accessible to pupils at all times.
5. Provides for student needs--as viewed by the student--more than any other type of activity.
6. Students have more freedom in this type of activity than in any other type.
7. Students have some freedom, but with certain restrictions imposed by the teacher. For example, only certain materials may be used.
8. Requires more different kinds of materials than other types of activities.
9. Likely to be a large-group activity.
10. After the activity gets under way, the teacher's role is mainly that of a helper and a guide.

The best responses to the items in the first exercise above are, in the writer's opinion, 1-E, 2-B, 3-A, 4-B, 5-D, 6-E, 7-A, 8-F, 9-C, 10-B. The best responses in the last exercise above are, in the writer's opinion, 1-B, 2-A, 3-B, 4-B, 5-B, 6-B, 7-A, 8-B, 9-A, 10-A.

References and Sources of Additional Information:

1. Robert Karplus and Herbert D. Thier, A New Look at Elementary School Science, (Chicago: Rand McNally and Company, 1967), pp. 65-66.

2. D. C. Ipsen, Issues in Elementary School Science, (Washington: National Science Teachers Association, 1970), pp. 12-13.

3. Priscilla J. Eccles, "Experiments, Demonstrations, and Other Types of First-Hand Experiences: A Classification and Definition of Terms," *Journal of Research in Science Teaching*, 3 (1963), 85-88.

4. Science-A Process Approach, *Part E, Exercise u*, (New York: Xerox Corporation, 1968), p. 4.

5. Quoted from an ESS Newsletter in: *Elementary Science Study: Program Report*, Elementary Science Information Unit, Far West Laboratory for Educational Research and Development, Berkeley, California, 1970, pp. 26-27.

6. Herbert D. Thier, *Teaching Elementary School Science - A Laboratory Approach*, (Lexington, Mass: D. C. Heath and Company, 1972), p. 196.

Types of Activities

Objective 1 - Pretest

Match the statements below with the following types of teacher initiated and directed activities:

A. An activity that could best be termed an experiment (conducted either by the teacher or by pupils).
B. An activity that could best be termed a demonstration (conducted either by the teacher or by pupils).
C. An activity conducted by the teacher for motivational purposes.
D. An activity, other than types B or F, in which pupils are primarily observers (usually under natural conditions).
E. An activity which proceeds step by step or in recipe fashion--as a result of the teacher or pupil(s) following specific directions.
F. Other: An activity centering around the use of books, films, filmstrips, records, tapes, pictures, television, lecture-discussion (and which do not involve the use of science equipment).

____ 1. Likely to be used in answering many science questions.
____ 2. Data is gathered which must be interpreted.
____ 3. Likely to be used in commencing a new unit, or at the beginning of a lesson.
____ 4. Before conducting this activity the teacher remarks: "Now watch the lime water turn milky as I blow through the straw and the carbon dioxide enters the lime water."
____ 5. This type of activity is used to show pupils how to cut glass tubing.
____ 6. Field trip to the sewage disposal plant.
____ 7. If one's primary purpose is to provide pupils with information, his activity would likely be of this type.
____ 8. Guest invited to class to show his collection of insects.
____ 9. Either teacher or students manipulate equipment for a specific purpose, and that purpose is to gather data for use in solving a problem.
____10. Used to illustrate or make clear a science concept, principle, or idea.

Types of Activities

Objective 2 - Pretest

Match the statements below with the following:

A. A teacher initiated and pupil directed activity (with teacher guidance)
B. A pupil initiated and pupil directed activity (with teacher guidance)

____ 1. A number of different ideas are being explored by pupils--but all pupils, or each group of pupils, have the same items of equipment.
____ 2. More informal and unstructured.
____ 3. The learning environment responds to children's initiation and explorations.
____ 4. Children have more opportunities to choose their own ends, but the teacher helps them to become good choice makers.
____ 5. These activities do not have to be restricted to science classes or specific periods.
____ 6. Only five pupils are working on science. Three of the five are working on different individual projects, and the other children are working together on a project.
____ 7. Children are usually not free to disengage from working with materials whenever they wish.
____ 8. There may be a time when the child is "between projects"--that is, he simply isn't working on science or in science.
____ 9. In-depth and long-range (over a long period of time) explorations are encouraged and hoped for.
____10. Likely to be terminated by the teacher.

Types of Activities

Objective 1 - Post-test

Match the statements below with the following types of teacher initiated and directed activities:

A. An activity that could best be termed an experiment (conducted either by the teacher or by pupils).
B. An activity that could best be termed a demonstration (conducted either by the teacher or by pupils).
C. An activity conducted by the teacher for motivational purposes.
D. An activity, other than types B or F, in which pupils are primarily observers (usually under natural conditions).
E. An activity which proceeds step by step or in recipe fashion--as a result of the teacher or pupil(s) following specific directions.
F. Other: An activity centering around the use of books, films, filmstrips, records, tapes, pictures, television, lecture-discussion (and which do not involve the use of science equipment).

____ 1. Students are usually told in advance of the activity what will happen and what to watch for.
____ 2. Used to promote positive mental set toward science study.
____ 3. The type of activity that may result when teachers are using unfamiliar curriculum materials.
____ 4. This activity is used when pupils do not know how to use or to assemble a particular piece of equipment.
____ 5. Probably the best way to simply expose pupils to a large amount of products of science.
____ 6. Used to clarify a science fact, principle, or generalization.
____ 7. A visit to a rock quarry.
____ 8. Much uncertainty may exist on the part of the teacher and the pupils as to how one part of the activity relates to other parts.
____ 9. Data gathered with this type of activity will be especially helpful in solving problems.
____10. "Scientific accuracy" might be thought of in connection with this type of activity.

Types of Activities

Objective 2 - Post-test

Match the statements below with the following:

A. A teacher initiated and pupil directed activity (with teacher guidance).
B. A pupil initiated and pupil directed activity (with teacher guidance).

____ 1. The role of the teacher as a facilitator and guide is probably more demanding.
____ 2. Opportunities for choice making by students are increased.
____ 3. Some pupils may be reluctant to begin--they may want to be told how to proceed.
____ 4. Children are more likely to want to share what they are doing with classmates--that is, tell others about their activities and projects.
____ 5. Teachers who encourage "science fair" projects use this type of activity and sometimes are not aware of it.
____ 6. When children tire of a science activity, or temporarily run out of ideas, they can work in some other area of their school program.
____ 7. A post-activity colloquium in which reactions to common experiences are explored, pooled, and shared, is less likely to be held after this type of activity than after the other type.
____ 8. Students must wait for science--the class schedule--not children--determines when they engage in science.
____ 9. Pupils may indicate a need or desire for materials not available.
____10. More pupils become more personally involved in science, but it takes time for many pupils to become personally involved in a project. They should not be rushed.

Developing a Proper Support System

~~This exercise was written primarily to enable the reader to:~~

1. Given the following:

   1. A teacher's preferred philosophical viewpoint (instructional or experiential).
   2. A teacher's preferred emphasis in science (products of science, processes of science, or development of children's potentials).
   3. A description of the materials component of the teacher's support system.
   4. A description of the additions to the materials component of the support system made by the teacher and the school within the past two months.
   5. A description of the teacher's skills and abilities in science (as reflected in a brief description of his training and teaching experience).

   Indicate which of the following are true:

   A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).
   B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).
   C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).
   D. The additions to the materials component of the support system made by the teacher and the school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).
   E. The teacher's probable skills and abilities are such that he could be expected to effectively implement the materials component of the support system (5-3).

2. In instances where the above statements are not true, explain why the statements are false.

Let's assume you are fond of animals and I offer to give you twelve goats, nineteen dogs, two cats and one horse if you will keep and care for them. Regardless of how much you like animals, you likely would not accept my offer. If I asked why you did not want them, you would likely reply: "I don't have a place to keep them and I can't afford to feed them." You would be telling me that you do not have a support system that is adequate to sustain thirty-four animals.

Now let's consider football for a few minutes. What are some of the major differences as football is played on elementary school playgrounds and as it is played when the Kansas City Chiefs meet the Green Bay Packers? All teams are likely composed of about eleven players. They use a football. They follow roughly the same rules. Both games are likely to attract spectators. Among the differences is the support system. The support system needed for the Chiefs-Packers game would include a large stadium, ticket sellers, persons who sell beer, hot dogs and peanuts, highly paid coaches, assistant coaches, trainers and players, expensive uniforms, a well-kept playing surface, etc. The support system needed for a game on an elementary playground would consist largely of a football, or a reasonable facsimile, and little else.

Just as the support system differs between elementary school football games and professional games, it differs for different approaches to elementary science. A teacher who uses an instructional approach needs a different support system than that needed for an experiential approach.

Instructional Approaches

Instructional approaches to science education are used when one is mainly interested in teaching science products and processes to children. Therefore, it is almost necessary that the teacher select or state the ends or objectives pupils are to work toward in instructional approaches. The approaches in which the teacher selects or states the objectives, and which are most likely to be used in teaching certain products and processes of science to children, are these:

1. The approach in which the teacher selects or states the ends and means, paces the learning activities, and provides large group instruction.

2. The approach in which the teacher selects or states the ends and prescribes the means, permits pupils to pace their own learning activities, and provides assistance to pupils individually.

3. The approach in which the teacher selects or states the ends, permits pupils to design their own learning activities or select learning activities from alternatives made available by the teacher, permits pupils to pace their own learning activities, and provides assistance to pupils individually.

Obviously, the support system needed for each of these approaches differs from that needed for the other approaches.

One of the first things that is needed when these approaches are used is a description of the science products and processes that are to be taught to pupils. Descriptions of what is to be taught can best be stated as instructional objectives. There are many reasons for believing that the more precise or specific the objectives are the better. (In other words, instructional objectives should be stated in behavioral terms.)

If you are now teaching and you are using science curriculum materials that call for the use of an instructional approach, and your materials do not contain fairly specific statements of what you are supposed to teach to your pupils, you may be somewhat dissatisfied with your science program. Your support system is inadequate (it lacks specific objectives) for the approach you are using.

Once the products and processes of science that are to be taught to pupils have been specified as instructional objectives, learning activities must be developed either by the teacher or by pupils which will enable students to meet the objectives.

If you are now using an instructional approach and are not satisfied with your program, perhaps one of the reasons is because your support system is inadequate in that the learning activities which you plan or the independent study materials devised by you or your pupils do not result in pupils learning the things you want them to learn.

Learning activities, whether large group or prescribed for individual children, require science materials, equipment, and supplies.

If a support system is limited to textbooks, an occasional film, and a few pieces of equipment such as a magnet, a few jars, and batteries that no longer work, obviously the support system is not adequate. What types of materials are needed to support an instructional approach? It depends upon the nature of the approach and the learning activities planned or prescribed, and these in turn depend upon the nature of the instructional objectives. If it is desired that pupils be able to name ten of the ninety-two natural elements, the support system should include lists of the elements.

If it is desired that pupils be able to explain the difference between the scientific definitions of heat and temperature, the support system should contain a good dictionary. If pupils are to demonstrate the pattern of a magnet's lines of force, some magnets, iron filings, and sheets of plastic will be needed, or pupils may devise some method which requires other materials.

An essential component of support systems for instructional approaches is evaluation. If it is desired that children learn certain things, and if an attempt is made to teach these things to children, the teacher who cares will be interested in finding out which children have learned and which have not so additional instruction can be provided those who have not learned. The nature of the tests or evaluation instruments depends upon the nature of the instructional objectives. Criterion-referenced tests should be selected or constructed which will reveal whether or not pupils have learned that which is specified in the instructional objectives.

Now let's turn our attention to the teacher as a part of the support system. Obviously, if an instructional approach is to be implemented effectively (and by effectively, I mean the pupils learn that which it is intended they learn), the teacher needs to be able to implement the approach. If a support system that is composed of a set of objectives, related learning activities, and the necessary materials, equipment, and supplies is available, all these things are rendered ineffective when placed in the hands of a teacher who is unable to use them as a total package or system.

Perhaps even more important than knowing how to use the various components of a support system, is a sincere belief on the teacher's part that the objectives--the descriptions of the products and processes of science pupils are expected to learn--are really needed by pupils. If the materials component of a teacher's support system is adequate and he knows how to use it, but does not really believe it is worthwhile for children to learn the products of science or acquire the processes of science specified in the instructional objectives, pupils are not likely to learn as much as they would if the teacher cared whether or not they learned.

In summary, some of the components that make up the support system needed for instructional approaches are these:

1. Instructional objectives - descriptions of the products and processes (and perhaps other things) children are to learn.
2. Learning activities - activities that enable children to master the objectives.
3. Equipment, materials, and supplies needed for implementation of the activities.
4. Criterion-referenced tests or evaluation instruments.
5. A teacher who knows how to use the above effectively.
6. A teacher who sincerely believes that children should master the program instructional objectives.

Is the support system needed for instructional approaches consistent with your philosophy? If it is and if you are now teaching, is your support system appropriate and complete? If it is not appropriate or complete, what is lacking?

Experiential Approaches

The major concern in experiential approaches is with the teacher providing pupils with experiences, and making available opportunities for experiences, which are believed to help children grow and develop their potentials. Among the necessary components of the support system for an experiential approach which are the same as for instructional approaches are these:

1. Materials, supplies, and equipment.
2. A teacher who sincerely believes in the approach.
3. A teacher who knows how to implement the approach.

Support systems for experiential approaches differ from those needed for instructional approaches in that formal evaluation plays a minor role in experiential approaches.

During experiential activities, some of the things that children should get an opportunity to do are these: (Obviously, not all of these would occur in each activity in which a child or group of children engages.)

1. To make some choices with respect to what they do and how they do it.
2. To feel successful as a result of completing worthwhile (to them) projects.
3. To work in areas in which they become personally involved.
4. To work with other children, share, question each other, disagree, and resolve intellectual conflicts.
5. To explore--to find out what happens if . . .
6. To be creative--to create and invent--to put objects and materials together in ways the teacher would never have thought of.
7. To wonder.
8. To use oral language frequently and written language when there is a legitimate need for it.
9. To share their ideas with classmates and the teacher.

What kind of support system, in addition to the things mentioned above, are needed to provide children with experiences which will permit them to engage in activities that result in their having opportunities to do many of these things? Let's consider each of the above types of opportunities and try to describe the conditions needed for each.

Making choices. Obviously, the support system must include many sets of materials, materials which may be manipulated in more than one way. For example, children might be permitted to choose between a record, a filmstrip, a book, a cassette tape, or working with batteries, bulbs, and wires.

Feeling successful. After materials have been made available, if needed, the teacher can assist the child in identifying a project that is manageable for him--one that he can complete successfully.

Becoming personally involved. When children are not personally involved in a project, they are willing to lay it aside. If they are personally involved, they will want to continue, or to come back to it at a later time. If they are given some choice as to what they do and how they do it, they will become personally involved in some projects and continue with them, and they will not become personally involved in other activities and will wish to pursue others.

Working with other children. Children should be permitted to move about the room if the occasion demands, to talk with each other about their work, and to share materials--all within reason, of course.

Exploring. In order to explore, children must be provided with objects and materials that interact--that do things. A child cannot do much exploring with a book, filmstrip, cassette tape, a page out of a workbook, or a set of questions run off on the duplicator. Children can explore with a set of objects such as these: mealworms, sandpaper, masking tape, water, medicine dropper, wax paper, and a soda straw. How does a mealworm react on sandpaper? On masking tape? When encircled in a ring of water on wax paper? When placed in a soda straw? The chances are, given these objects, children will find other objects to use along with them.

Being creative. (The statements above under Exploring would set the stage for the expression and development of creativity.)

Wondering. Support systems for experiential approaches should include objects that lead children to wonder and which permit them to explore and satisfy their curiosity. Most children wonder what certain objects look like under a microscope. Some wonder what is inside a wasp's nest or a flashlight battery. Some might wonder whether or not the larval stage of mealworms eat those in the adult stage. If these things (microscope, wasp's nest, mealworms, etc.) are not available, children are not likely to wonder about them; and if they do wonder, they will be unable to satisfy their curiosity.

Using oral language. If students have things to talk about, and are permitted to talk, they will talk. Little provision needs to be made for this, but permission must be granted. A quiet classroom used to be considered a good classroom. Today, a classroom where children are not permitted to talk when they are engaged in certain projects is considered unnatural. Not permitting children to talk surely contributes to some children being stunted intellectually, in their ability to use language, socially, and perhaps in other ways.

Sharing ideas. Children who are personally involved in projects believe their projects are important and many times want others to know what they are learning or trying to find out. Opportunities for sharing should be provided.

Any approach to science, whether instructional or experiential, requires an appropriate and adequate support system. A support system is composed of two major components: (1) materials (including curricular materials), equipment, and supplies, and (2) the skills and abilities of the teacher. However, the teacher component of the support system is probably as important or perhaps more important than the materials component to the success of a science program.

What a teacher believes and values surely has tremendous influence upon his science program. If what the teacher believes and values is backed up or supported by the proper kinds and amounts of curriculum materials, equipment, supplies, etc., and if the teacher has the skills and abilities to make his beliefs and values come alive in the classroom, the chances are great that the science program will be good. If the teacher's beliefs and values are not well thought out and established, and if the teacher is not supported with appropriate curriculum materials, equipment, and supplies, and if the teacher lacks skills essential to the implementation of an approach, the chances are slim that the science program will be good.

Teacher Beliefs and Support System

The following pages contain information about two teachers. Letter your paper A, B, C, D, and E, then answer these questions which are based on the information provided by the first teacher--Alice Lambert. (It is suggested that you review the objectives for this exercise before responding.)

True or False (If false, explain why)

A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).

B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).

C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).

D. The additions to the materials component of the support system made by the teacher and the school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).

E. The teacher's probable skills and abilities are such that she should be able to effectively implement the materials component of the support system (5-3).

Alice Lambert has provided the following information:

1. Preferred philosophical viewpoint: Experiential

2. Preferred emphasis in science: Development of children's potentials

3. Description of the materials component of her science support system:

   Each child has a text. The school bought a kit of materials at the time the texts were bought, but the consumable items haven't been replaced. I bring some things from home occasionally and encourage pupils to do so--but they seldom do. As a result, we don't do many of the activities suggested in the manual. We have a set of science encyclopedias. We also have a number of filmstrips on science and can get 16mm films from the local university. I sometimes devote a bulletin board to science. We have a "science table" in the room and I encourage students to bring things for show-and-tell period, then we place the items on the science table for a few days. At present, the table has some walnuts, a hornet's nest, the skull of a small animal, a book of science experiments for children, and a magnet like those veterinarians place in the stomach of cows when they swallow metal objects.

4. Additions to materials component of support system within past two months:

   1. School subscribed to Ranger Rick magazine. Magazine is given to each room for a period of one week.
   2. A book of science experiments for children titled Fun with Science. (Brought in by a pupil.)
   3. About a dozen walnuts.

5. Description of teacher's skills and abilities component of her support system (as reflected in training and experience):

   I had three hours of biology and three hours in geology. I had a science methods course about five years ago. The instructor in the methods course spent most of the time on weather--I think it was his specialty. The major project in the course was for each student to construct some type of simple weather instrument and report to the class how it was made and how it worked. I have taught third grade four years--mostly from textbooks.

Correct Responses:

A. The teacher's preferred viewpoint and emphasis in science are consistent. True.

B. The teacher's preferred philosophical viewpoint (experiential) is not consistent with the materials component of her support system. False. The viewpoint reflected in today's textbooks is instructional.

C. The teacher's preferred emphasis in science and the materials component of her support system are not consistent. False. The teacher prefers to emphasize the development of children's potentials, while today's textbooks serve mainly to emphasize the products of science.

D. The additions to the materials component of the support system within the past two months are inadequate. False. While those things added may be of the right type--considering the nature of the support system--they are inadequate from the standpoint of amount. Other types of things need to be added to the support system.

E. The teacher's probable skills and abilities, as is reflected in the brief description of her training and experience, indicate she can probably implement the materials component of the support system--such as it is. True.

A reasonable inference concerning the above teacher is that she is being forced, either by school officials or by a support system, or both, to emphasize something (the products of science) that she does not value, and to use an approach (instructional) which she would rather not use. (This may partly account for the limited additions to the materials component of the support system.) Therefore, it is not likely that this teacher is very conscientious in teaching science.

Letter your paper A-E and answer the five true-false questions given earlier, but base your responses on the information provided by a second teacher--Tom Samuels--which follows:

Tom Samuels teaches fifth grade and has provided the following information:

1. Preferred philosophical viewpoint: Instructional.

2. Preferred emphasis in science: The products of science.

3. Description of materials component of support system.

   We have a number of small kits. Each kit has an independent study guide with specific objectives, and learning activities that are supposed to enable each child to learn the objectives. Most of the kits contain cassette tapes and filmstrips and student answer sheets. Students listen to the tapes and follow the directions and record their answers.

4. Additions to the materials component of support system within the past two months: Storage cabinets for all kit materials.

5. Description of skills and abilities as reflected in training and experience.

   I took eighteen hours in science--most of it lecture. I thought I had a fairly good background in science, but I haven't used much of what I learned and now feel rather weak in science. (I really don't have to know much, though, because of the type of program we have in our school.) I had a combination math-science methods course. Most of the time that was devoted to science was spent searching through books for activities we thought would be interesting to kids and conducting them with our classmates.

Correct responses:

A. True.

B. True.

C. True.

D. Evidently the school bought a "complete package" since the program is composed largely of cassette tapes and filmstrips and other independent learning materials. If this is the case, one wouldn't expect the teacher to make additions to the support system in the same manner he might with some other programs. The additions are probably reasonable in amount and type. True.

E. There isn't anything in the description of the teacher's training to indicate he is able to implement successfully a set of individualized or independent study materials which are developed around specific objectives and which are intended to lead to student mastery of the objectives. False. (Perhaps the kit materials are such that few teacher skills and abilities are needed in guiding students as they work with the kits.)

This teacher's program depends more upon the independent learning materials than upon other factors. However, the teacher can either be conscientious in seeing to it that his pupils work through the materials, or he can be lax and communicate to his pupils that he cares little whether or not they use the materials. Inasmuch as the materials were developed with the instructional approach in mind, and since the products of science are probably emphasized in the materials, this teacher is likely conscientious in assisting his pupils in learning the program objectives.

Summary

Many things affect the nature and quality of an individual teacher's science program or a school's science program. Among them are the teacher's philosophy or beliefs and personal preferences, and the support system which is composed of two major components: curricular materials and equipment and the skills and abilities of the classroom teacher.

Science programs in which all of these things are consistent and compatible are much more likely to be effective than programs in which these things are inconsistent and inadequate.

Developing a Proper Support System

Objectives 1 and 2 - Pretest Response Sheet (One of three)

Below are statements which relate to the attached information about Jack Dossett. If a statement is true, write "True" on the line below the statement. If a statement is false, explain on the lines below the statement why you believe it to be false:

A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).

____

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B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).

____

____

C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).

____

____

D. Assuming the teacher has no choice other than to implement the school science program (the materials component of the support system), the additions to the support system made by the teacher or school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).

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E. The teacher's probable skills and abilities are such that he could be expected to effectively implement the materials component of the support system (5-3).

____

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Teacher: Jack Dossett (Grade four)

1. Preferred philosophical viewpoint: Instructional

2. Preferred emphasis in science: Believes the products of science should be emphasized

3. Description of the materials component of the support system:

   A textbook for each child and a teacher's manual. I usually search for materials for each activity a day or so before it is to be conducted. Some needed items can't be located, and some are too expensive. I have a specially built box to fit on my desk so all pupils can see when we conduct an experiment.

4. Additions to materials component of support system made within the past two months:

   A filmstrip about invertebrates
   Balloons
   Teacher-made equal arm balance
   Spool of fine wire
   Candles
   Broom handle
   Red and green cellophane paper
   Cotton swabs
   Paper cups
   Alcohol
   Screw driver
   A number of glass and plastic containers

5. Description of probable skills and abilities in science (as reflected in training and teaching experience):

   Took twenty-two semester hours in science as undergraduate. "Methods" was taught in conjunction with two courses. Biology and physics teachers team-taught "methods" units. "Methods" units dealt with:

      Objectives of elementary science
      Planning for teaching
      Science activities for elementary pupils
      Creativity in teaching
      Asking questions in science
      Evaluating science learnings

   This is my first year of teaching.

Developing a Proper Support System

Objectives 1 and 2 - Pretest Response Sheet (Two of three)

Below are statements which relate to the attached information about Mabel Sundberg. If a statement is true, write "True" on the line below the statement. If a statement is false, explain on the lines below the statement why you believe it to be false:

A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).

B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).

C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).

D. Assuming the teacher has no choice other than to implement the school science program (the materials component of the support system), the additions to the support system made by the teacher or school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).

E. The teacher's probable skills and abilities are such that he could be expected to effectively implement the materials component of the support system (5-3).

Teacher: Mabel Sundberg (Grade One)

1. Preferred philosophical viewpoint: Experiential

2. Preferred emphasis in science: Believes emphasis should be placed upon the development of each child's potentials

3. Description of the materials component of the support system:

   "I have collected and put together a number of small 'kits' that are problems and games on cards that involve a variety of materials. Pupils either do the problems and games individually or in pairs. I have one microscope and several jars of water that contain a variety of microscopic life. Gerbil. Three white mice in cage with exercise wheel. A variety of books for children on many science topics. A number of boxes of materials - each box contains a set of objects that can be used in many ways. For example, one box contains three vials of different liquids, five different types of powdery substances, wax paper, and droppers."

4. Additions to materials component of support system made within the past two months:

   ESS units: Geo Blocks - (a set of unfinished hardwood blocks that come in a wide range of shapes and sizes that make possible a great variety of structures and designs)
   Mirror Cards - (a box of 21 sets of cards with colorful pictures and patterns. Problems posed are matching, by means of a mirror, a pattern on one card with a pattern shown on another card.)
   Attribute Games and Problems - (colorful materials - A-Blocks, People Pieces, colored loops, stickers and labels - are used to solve a variety of problems which are intended to aid the development of thinking skills.)

   Incubator and eggs

5. Description of probable skills and abilities in science (as reflected in training and teaching experience):

Twelve semester hours in science - four in physics, four in biology, and four in earth science - all mostly lecture-demonstration, little lab. Methods course in which each student had to construct a teaching unit composed of specific objectives, lesson plans for large-group instruction, learning activities appropriate to the objectives were included, and notes on how each activity could be correlated with other subjects were included.

Taught first grade five years. Did not teach science first four years.

Developing a Proper Support System

Objectives 1 and 2 - Pretest Response Sheet (Three of three)

Below are statements which relate to the attached information about Jean Strader. If a statement is true, write "True" on the line below the statement. If a statement is false, explain on the lines below the statement why you believe it to be false:

A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).

____

____

B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).

____

____

C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).

____

____

D. Assuming the teacher has no choice other than to implement the school science program (the materials component of the support system), the additions to the support system made by the teacher or school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).

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E. The teacher's probable skills and abilities are such that he could be expected to effectively implement the materials component of the support system (5-3).

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Teacher: Jean Strader (Grade Three)

1. Preferred philosophical viewpoint: Instructional

2. Preferred emphasis in science: Believes the processes of science should be emphasized

3. Description of the materials component of the support system:

   Her school recently purchased a new K-6 science program. Included are teachers' manuals with about twenty sections or exercises for each grade. Each exercise contains two or three specific objectives that are said to be process-centered, and suggested learning activities for each objective. Each exercise also contains tests to be used in determining whether pupils have mastered the objectives. Objectives are taught and should be mastered by pupils in a specified sequence. All pupils learn to master the same objectives at the same time.

   Kits of materials are provided that contain many of the items needed for use with a class of about 30 pupils.

4. Additions to materials component of the support system made within the past two months:

   All needed materials not supplied in the kits have been obtained. Items such as these have been added:

   Two guinea pigs
   Flashlight dry cells (16)
   Brass paper fasteners
   Masking tape
   Two coffee cans
   One tennis ball
   One rubber ball
   Darning egg
   Eighteen clothespins
   One liter of soil

5. Description of probable skills and abilities in science (as reflected in training and experience):

   Had four hours of biology and four hours of physical science as an undergraduate seven years ago. Did not have a science "methods" course, but recently completed a thirty-hour in-service workshop in which she learned many of the process skills she is now teaching her pupils.

Developing a Proper Support System

Objectives 1 and 2 - Post-test Response Sheet (One of three)

Below are statements which relate to the attached information about Angela Hockensmith. If a statement is true, write "True" on the line below the statement. If a statement is false, explain on the lines below the statement why you believe it to be false:

A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).

____

____

B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).

____

____

C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).

____

____

D. Assuming the teacher has no choice other than to implement the school science program (the materials component of the support system), the additions to the support system made by the teacher or school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).

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E. The teacher's probable skills and abilities are such that she could be expected to effectively implement the materials component of the support system (5-3).

____

____

Teacher: Angela Hockensmith (Grade four)

1. Preferred philosophical viewpoint: Instructional

2. Preferred emphasis in science: Believes the products of science should be emphasized.

3. Description of the materials component of the support system:

   School recently purchased a new K-6 science program. Included are teacher's manuals with about twenty sections or exercises for each grade. Each exercise contains two or three specific objectives that are said to be process-centered, and suggested learning activities for each objective. Each exercise also contains tests to be used in determining whether pupils have mastered the objectives. Objectives are taught and should be mastered by pupils in a specified sequence. All pupils learn to master the same objectives at the same time.

   Kits of materials are provided for use with about 30 pupils.

4. Additions to materials component of the support system made within the past two months:

   All needed materials not supplied in the kits. Items such as these have been added:

   Two guinea pigs
   Flashlight dry cells (16)
   Brass paper fasteners
   Masking tape
   Two coffee cans
   One tennis ball
   One rubber ball
   Darning egg
   Eighteen clothespins
   One liter of soil

5. Description of probable skills and abilities in science (as reflected in training and experience):

   Had four hours of biology and four hours of physics as an undergraduate. Did not complete a science methods course but recently completed a thirty-hour in-service workshop in which she learned many of the process skills she is now teaching her pupils. First year teacher.

Developing a Proper Support System

Objectives 1 and 2 - Post-test Response Sheet (Two of three)

Below are statements which relate to the attached information about Margaret Allison. If a statement is true, write "True" on the line below the statement. If a statement is false, explain on the lines below the statement why you believe it to be false:

A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).

____

____

B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).

____

____

C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).

____

____

D. Assuming the teacher has no choice other than to implement the school science program (the materials component of the support system), the additions to the support system made by the teacher or school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).

____

____

E. The teacher's probable skills and abilities are such that she could be expected to effectively implement the materials component of the support system (5-3).

____

____

Teacher: Margaret Allison (Grade One)

1. Preferred philosophical viewpoint: Experiential

2. Preferred emphasis in science: Development of children's potentials

3. Description of the materials component of the support system:

   Materials recently purchased by school titled Experiential Science Program includes:

   Teacher's Big Book of Bound Study Prints: Living Things
   Teacher's Big Book of Bound Study Prints: The Physical World
   Pupil's activity book to correlate with each of the "Big Books"
   Process/Concept Enrichment books with these titles:
   The Five Senses
   Things Around Us
   Place and Space
   One and More
   How Much-How Many
   All and Part

4. Additions to materials component of the support system made within the past two months:

   Six filmstrips: "Simple Machines"
   Six 8mm film loops on plants and animals
   Four children's science books: Rocks, Weather, Insects, Birds

5. Description of probable skills and abilities in science (as reflected in training and experience):

   Completed nine semester hours of science about twelve years ago. Recently completed a science methods course as part of graduate work in which emphasis was placed upon micro-teaching (teaching small groups of students short periods of time) in which children were provided with a number of objects and were encouraged to engage in free exploration under teacher guidance.

   Eighth year of teaching first grade. First year of teaching new science program--taught seven years with traditional textbooks.

Developing a Proper Support System

Objectives 1 and 2 - Post-test Response Sheet (Three of three)

Below are statements which relate to the attached information about Myrtle Castleberry. If a statement is true, write "True" on the line below the statement. If a statement is false, explain on the lines below the statement why you believe it to be false:

A. The teacher's preferred philosophical viewpoint and emphasis are consistent (1-2).

____

____

B. The teacher's preferred philosophical viewpoint and the materials component of the support system are consistent or compatible (1-3).

____

____

C. The teacher's preferred emphasis in science and the materials component of the support system are consistent or compatible (2-3).

____

____

D. Assuming the teacher has no choice other than to implement the school science program (the materials component of the support system), the additions to the support system made by the teacher or school within the past two months are reasonable in amount and type in light of the nature of the program and the major emphasis of the program (4-3).

____

____

E. The teacher's probable skills and abilities are such that she could be expected to effectively implement the materials component of the support system (5-3).

____

____

Teacher: Myrtle Castleberry (Grade Three)

1. Preferred philosophical viewpoint: Instructional

2. Preferred emphasis in science: Believes the products of science should be emphasized.

3. Description of the materials component of the support system:

   (As described in publisher's brochure)

   . . . a multimedia program. Included are audio tapes, filmstrips, books and other printed materials, games, and manipulative materials--most designed for independent use by the student.

   Each "lesson" in the program is complete; that is, it is a prepackaged kit that includes most of the materials necessary for the satisfactory completion of that specific lesson, or explains to the student where he can get what he needs to complete the lesson.

   Tapes, in standard cassette form are used at the lower levels where most children have a limited reading vocabulary.

   In order to provide pupils with the opportunity to make choices, alternatives are provided through Mainstream or core materials, and Alternative Pathways. The Mainstream includes basic core information. Mainstream lessons are completed in sequence and each student is expected to master this material. A student may interrupt the Mainstream sequence and choose an alternative pathway that is of interest to him.

4. Additions to materials component of the support system made within the past two months:

   Cassette tape player
   Storage containers for filmstrips and tapes
   All materials needed but not supplied in prepackaged kits, such as water, ice cubes, plants and animals.

5. Description of probable skills and abilities in science (as reflected in training and experience:

   Completed six semester hours of science as an undergraduate many years ago. Never had a science methods course. Taught many years from a textbook with most lessons devoted to reading and discussion of text material.

   Does not care to reveal the number of years experience she has had.

Improved Science Programs

This exercise was constructed primarily for the purpose of enabling the reader to:

1. Given a list of statements which describe or reflect one of three modern science programs, indicate which of the following programs is best described or reflected in each statement:

   A. Elementary Science Study (ESS)
   B. Science-A Process Approach (SAPA)
   C. Science Curriculum Improvement Study (SCIS)

Learning Activities and Materials:

1. View the ESS, SAPA, and SCIS filmstrip-tape programs and read the descriptive brochure for each program contained in the ELEMENTARY SCIENCE INFORMATION UNIT. (Produced by: Far West Laboratory for Educational Research and Development, 1 Garden Circle, Hotel Claremont, Berkeley, California 94705). These materials are located:

   ____

2. Read the materials in the packet provided by the instructor which contains pamphlets, brochures, newsletters, etc., concerning the three programs.

3. Read the following articles:

   "Programs for Improving Science Instruction in the Elementary School: Part I, ESS." (Science and Children, January/February, 1970, pp. 34-42).

   "Programs for Improving Science Instruction in the Elementary School: Part II, SCIS, (Science and Children, May, 1970, pp. 29-36.

   These materials are located:

   ____

4. Examine teacher's guides and other available materials for each of the programs. These materials are located:

    ____

5. Attend showing of available films and video tapes in which children and teachers use the above programs.

6. If possible, observe in nearby schools where classes in action are using either the ESS, SAPA, or SCIS program.

7. See suggested guides below.

Use the following questions as a guide as you engage in the learning activities:

1. Which of the following seems to have been the major source of the objectives in each program?

    A. Subject matter
    B. The ways scientists think and work
    C. Children
    D. Society

2. Which of the following have authors of each program intended should be emphasized by teachers who use the program?

    A. The products of science
    B. The processes of science
    C. The development of children's potentials
    D. Other than the above

3. To what extent has individualized instruction been provided for, that is,

    A. Who (teacher or pupils) select(s) the ends?
    B. Who (teacher or pupils) select(s) the learning activities?
    C. Who (teacher or pupils) pace(s) the learning activities?
    D. Do pupils receive guidance from the teacher individually, in small groups, or as one large group?

4. Which of the following philosophical viewpoints is reflected in each program:

   A. Instructional
   B. Experiential
   C. Combination of both

5. If an experiential approach is to be used in implementing a program, to what extent do you believe the experiences which teachers might plan for children and permit them to select would contribute to the development of children's potentials?

   A. To a great extent
   B. To a moderate extent
   C. Little or none

6. If an instructional approach is to be used in implementing a program, which of the following components of the instructional approach are obviously built into the program and which are lacking or not used?

   A. Specific or behavioral instructional objectives
   B. Pretests or preassessment instruments
   C. Suggested instructional activities
   D. Practice - when appropriate
   E. Post-tests or post instruction evaluation instruments

7. Which of the following types of statements have the authors of each program provided teachers to focus their attention upon when planning, directing, and evaluating instructional or learning activities:

   A. Science problems
   B. Science questions
   C. Behavioral objectives
   D. Vague objectives
   E. Science concepts, principles, and generalizations
   F. Means oriented statements describing teacher activities or responsibilities
   G. Means oriented statements describing student learning activities
   H. None or statements other than the above

8. Will most activities in which children engage likely be

   A. Initiated and directed by the teacher
   B. Initiated by the teacher and directed by pupils
   C. Initiated and directed by pupils
   D. Initiated and directed by independent learning materials or guides

9. How well defined is the role of the teacher in implementing the program, or what is the nature of the teaching skills component of the support system needed for implementing the programs according to the recommendations of the authors?

10. To what extent is each program consistent with your developing philosophy of science education?

   A. To a great extent
   B. To a moderate extent
   C. Little or none

Improved Science Programs

Objective 1 - Pretest

Indicate which of the following science programs is best described or reflected in each of the statements below:

A. The Elementary Science Study Program
B. The Science - A Process Approach Program
C. The Science Curriculum Improvement Study Program

Statements concerning sources of objectives, emphases, and related considerations:

1. An important purpose is to provide the student in the elementary grades with some highly generalizable intellectual skills, and some knowledge of scientific procedures for gaining new knowledge. A related aim is that of providing the child with the kind of knowledge that is generalizable to new situations.

2. The program was not developed with concern for the structure of science, for the way scientists think and work, or for the needs of society.

3. The overall program is structured around the fundamental concepts of physical and biological sciences and the concepts are organized into ascending levels of abstraction.

4. A major goal is "scientific-literacy" - the functional understanding of basic science concepts, and an understanding of the structure of science.

5. Children learn process skills which carry the promise of broad transferability across many subject matter areas.

6. It is the contention of ______________ that viewing children as growing, self-actualizing (fulfilling one's potentialities) individuals is consistent with its approach to children's learning science.

Statements concerning the materials component of the support system:

7. A student manual is included that is an organizational aid to assist in keeping records. This manual is not a traditional type of workbook, but is specifically designed to promote organizational skills and to keep records.

8. The program is not bounded by disciplines nor fenced off by conventional frontiers. Materials have been developed simply as self-contained units, each providing experience in a particular exploration; each varying in subject matter, apparatus, level of complexity, and style of presentation; each guided by basic threads of scientific investigation-inquiry, evidence, instrumentation, measurement, classification, deduction.

9. The exercise begins with a statement of Objectives in terms of what skills the child should have after the exercise has been completed. The Rationale tells the teacher why the exercise is included in the sequence and in many cases provides some helpful background information. The Vocabulary lists words that have not been used in previous exercises. The Materials list aids the teacher in identifying the necessary supplies.

10. Interrelationships are not emphasized between the science ideas or concepts found in the various units. The attempt is to present interesting and meaningful individual packages on topics in science which can either be placed together to form a total program or used as a supplement to a school's present program.

11. Each exercise is designed to achieve some clearly stated objectives. These are phrased in terms of the kinds of pupil behavior which can be observed as outcomes of learning upon completion of the exercise.

12. Titles of some units: Seeds, Mealworms, Mystery Powders, Bones, Pendulums, Gases and Airs, Kitchen Physics, Colored Solutions, Mirror Cards, Peas and Particles.

13. The exercises are ordered in sequences of instruction to provide a developmental progression of increasing competence in the processes of science.

14. Part of the program is composed of the following sections and topics:
    Using Numbers 5: Numbers and the Number Line
    Observing 10: Observing the Weather

16. The exercises in this program have been ordered on the basis of complexity of behaviors which the children are to acquire.

17. One section of the teacher's guide contains these instructions to the teacher: "With the class, review the results of each of the groups in the previous activity. Ask, In what way were all of the investigations the same? Review the list from Activity 1. Ask, Was the time the cylinder takes to roll down the incline one of the variables? (Yes) Explain that what they did was to manipulate one variable and to observe the response of another."

Statements concerning the teaching skills component of the support system:

18. The teacher must be able: (1) to accept children's active, direct participation in and analysis of their science experiences; (2) to function more often as observer and guide than as demonstrator and lecturer; (3) to operate in a classroom situation where the noise level is often high and the student activity great; (4) to accept a diversity of responses from children; and (5) to assess what students say and do for evidence of their understanding of what is being studied.

19. The teacher mainly supports what the students do. He creates a classroom atmosphere that encourages students to observe, manipulate, and experiment with materials; to ask questions; to express and test out their ideas and to discuss their activities among themselves and with the teachers.

20. The teacher's role is one of consultant, guide, and catalyst. The teacher advises, listens, diagnoses, and acts as an external loop, doing things for the child that he cannot do for himself. For this reason, the teacher must see the child as having an extraordinary capacity for learning and believe that he learns best from his own activity.

21. The teacher directs students in these ways: (1) by asking questions which encourage students to extend their observations and experiments; (2) by asking, when necessary, questions that focus students' attention on a specific object or event; (3) by involving students in discussion and review of their laboratory experiences; (4) by suggesting possibilities for extending old or new experiments; (5) by selecting a variety of appropriate activities and providing materials; and (6) by using the student activity pages, or manuals, games, and other learning devices to illustrate the meaning and application of a concept.

Statements concerning implementation consideration:

22. Teachers may question the value of certain materials when the children appear to be only playing with them, yet it may be at these times that the children are assimilating the most information about them.

23. Different kinds of lessons are involved. One kind introduces or "invents" a new concept, while the other kind is designed to help the children discover the usefulness of the new concept.

24. This general format is followed in teaching: the introduction, in which the teacher attempts to arouse interest, showing or demonstrating the materials, asking questions; one or more activities, the main part of the lesson; one or more generalizing experiences, in which students apply what they learned in the activities; and evaluation in the form of a competency measure and/or appraisal.

25. The children use materials themselves, individually or in small groups, often raising the questions themselves, answering them in their own way, using the materials in ways the teacher had not anticipated, and coming into their own conclusions.

26. This program intends children's learning to be "discovered" rather than "parroted" from a teacher's lecture or "copied" from a demonstration. But it has eliminated the elements of randomness and chance associated with an "open-ended" search. Each set of lessons is structured so that there is little risk that its objective will be delayed or sidetracked by "messing about" with activities characteristic of some of the other curricula.

27. The thinking is that children learn more when they are doing what they want to do instead of what someone else wants them to do.

Statements concerning evaluation:

28. The appraisal assesses the acquisition by the children of the behaviors prescribed by the objectives of the exercise.

29. ...achievement can be measured in terms of the student's ability to demonstrate understanding of concepts verbally and operationally. Opportunities for the teacher to check this understanding arise through...the classroom strategy followed in developing each concept. The teacher can observe and find clues to a student's misunderstanding in: his selection, initiation and execution of experiments to test a concept; his manipulation of materials and equipment; his participation in and contributions to group discussions; his responses to convergent and divergent questions; his ability to verbalize about a concept and related activities; and his attempts to apply a concept with different materials and experiments.

30. Neither prepared tests nor behavioral objectives are provided for teachers to use to test student performance. Some questions the teacher might ask to gauge involvement are:
    Do the children enjoy working with the materials?
    Are their conversations in class - discussions or arguments?
    Do they persist over a period of days, weeks, or months on things which capture their interest?
    Do they exhibit any initiative, have they developed any skill in finding out what they want to know?
    Can they afford to make mistakes freely and profit from them?
    Do they know how to get help when they need it and to refuse help when appropriate?

Improved Science Programs

Objective 1 - Post-test

Indicate which of the following science programs is best described or reflected in each of the statements below:

A. The Elementary Science Study Program
B. The Science-A Process Approach Program
C. The Science Curriculum Improvement Study Program

Statements concerning sources of objectives, emphases, and related considerations:

1. The goal in education is not to increase the amount of knowledge, but to create the possibilities for a child to invent and discover.

2. The concepts around which the materials have been developed are representative of the "big ideas" in science, (i.e., organism, ecosystem, matter and energy, property, reference frame, system, and model).

3. Designed to teach to children the ". . . distinct intellectual processes--essentially the ones the scientist uses-- . . . in a highly systematic way."

4. Goals are intentionally not specified; materials and activities for a "science experience" that will lead students and teachers to set their own goals. . . .

5. The most striking characteristic of these materials is that they are intended to teach children the processes of science rather than what may be called science content. That is, they are directed toward developing fundamental skills required in scientific activities.

6. One of the important objectives . . . is the development of the child's concept of himself and his abilities.

Statements concerning the materials component of the support system:

7. Each teacher's guide sets out the behavioral objectives, outlines and explains the teaching context into which the activities fit, sets forth the steps to take in teaching, provides tests of pupils' learning, and lists new vocabulary words which the pupils should learn.

8. Successive exercises build upon earlier exercises in a progressive sequence.

9. The student manual is one of your teaching aids; it is not the mainstay of the course. During some activities the children record information about their experiments in the manual for later discussion. Encourage the children to make their entries independently even though their reports may disagree with those of other students or with what you consider to be the correct response. Some children may change their minds later.

10. Some units are designed for individual or small group work. These units lend themselves well to meeting individual needs and interests of different children.

11. Part D concentrates on variables. Students learn to describe, classify, measure, quantify, and infer variables. Variable description is illustrated by such topics as bouncing balls, growth of plants and their parts, construction and interpretation of maps, relative position and motion, and describing and representing forces.

12. The sequence indicates the prerequisites for the exercise.

13. Two or more activities are provided which are aimed at teaching the same objectives. In addition, directions are given for still another activity which is taught to the entire class at one time and which provides the teacher with immediate feedback on what the class as a whole can do.

14. The emphasis is on children's experience with materials with little emphasis given to organization within a sequence. Each unit stands on its own, and although teachers are encouraged to find and use relationships between units, the relationship is not spelled out for them. . . . feels that the choice of units is not very important.

15. Titles of some units: Organisms, Life Cycles, Populations, Material Objects, Subsystems and Variables, and Energy Sources.

Statements concerning the teaching skills component of the support system:

16. Teacher training: No specialized science training needed; ability to be non-directive highly desirable.

17. The teacher needs to be able to use three classroom strategies: Exploration--in which the child explores with materials with minimal guidance, invention--in which a definition and a term for a new concept is provided, and discovery--in which the child discovers a new application for a concept.

18. The atmosphere in a ____________ classroom is relaxed and yet controlled. The __________ teacher has two functions: to be an observer who listens to the children and notices how well they are progressing in their investigations, and to be a guide who leads the children to see the relationship of their findings to the key concepts of the course. The teacher is not thought of as a pivot around which the whole class revolves, and is not expected to summarize each lesson or to tie up loose ends into a neat package.

19. The teacher does not simply tell the student, but guides him with skillful questions to identify important problems and discover answers for himself. The teacher plays a central role in providing experiences that insure the learning of process skills in each exercise.

Statements concerning implementation considerations:

20. This program may be introduced into grades K-3 at the same time because the sequential development of skills is not a crucial factor at the primary level. In grades 4-6, however, students draw upon skills taught in the earlier grades. It may be advisable, therefore, to introduce the curriculum grade by grade at the upper level.

21. Since each lesson is designed to be taught in a fairly structured, step-by-step sequence, the teacher needs to familiarize himself with the explicit instructions in the teacher's guide. He should understand the procedures required and have obtained the materials to be used.

22. Children could be allowed to "mess about" with materials in the early phase of a unit, the rationale being that preliminary free and unstructured experience (messing about) with the materials "produces the early and indispensable autonomy and diversity" that serves to give meaning and direction to children's questions and activities. This approach permits children to learn different things and to learn at different rates.

23. In summary the ______________ approach to the teaching of science is as open-ended and unstructured as possible with the only restriction being that children must be able to have the experiences for themselves.

24. . . . strong emphasis on non-directive approach and student initiated activities and explorations.

25. . . . an environment in which each child can make his own observations, ask his own questions, perform his own experiments, and draw his own conclusions.

26. Some lessons involve objects that are so intriguing to the children's manipulative and investigative tendencies that opportunity for them to explore must necessarily precede any attempt to teach the intended concept.

27. Students accustomed to being dependent learners do not readily accept the responsibility for their own learning. They have to assume this responsibility gradually, as they gain self-confidence.

Statements concerning evaluation:

28. The evaluation, which is completely based on behavioral objectives, is an extremely important part of the program and reflects the highly structured nature of the approach.

29. The student manuals or activity pages which require written work are one means of evaluation.

30. The most satisfactory way to find out whether a child is learning is to see whether he is involved with the materials.

Correct Responses to Pretests

1. Ends and Means and Pacing Learning Activities

Objective 1: 1-M, 2-E, 3-E, 4-M, 5-M, 6-E, 7-E, 8-E, 9-M, 10-E, 11-M, 12-M, 13-M, 14-E, 15-M

Objective 2: 1-P, 2-P, 3-P, 4-T, 5-T, 6-T, 7-T, 8-P, 9-T, 10-T

2. Alternative Approaches in Elementary Science Education

Objective 1: 1-PPPI, 2-TTPI, 3-TTPI, 4-PPPI, 5-TTTL, 6-TTTL, 7-TTPI, 8-PPPI, 9-TTTL, 10-TTTL

Objective 2: (Many different responses are acceptable)

Example: A - if teacher underlined -

"By training, background, and experience the teacher is better able to select relevant objectives within the child's capabilities."

Example: A - if pupil underlined -

"I believe it is humanly impossible for a teacher to select objectives that meet the needs and interests of a large group of children with different abilities."

Example: B - if teacher underlined -

"In my opinion, this is what the teacher is paid to do!"

Example: B - if pupil underlined -

"There is more pupil interest in student selected learning activities."

Example: C - if teacher underlined -

"Most schools (mine included) do not have the materials for student-paced learning."

Correct Responses to Pretests (cont'd)

Example: C - if pupil underlined -

"Pupils should be allowed to progress at their own rate."

Example: D - if one large group underlined -

"I think most children benefit from the same unit and can learn from each other from sharing their experiences."

Example: D - if individually underlined -

"The needs of the individual child cannot be met in group instruction."

3. Individualizing Instruction

Objective 1:

	A	B	C
1	x	x	x
2			x
3			
4			
5		x	x
6	x	x	x
7			
8			
9	x	x	x
10			

4. Sources of Objectives and Emphases in Science Education

Objective 1: (The order below is not important; however, the A and B responses should correspond as below.)

1A	Subject matter	1B	Products of science
2A	Ways scientists think and work	2B	Processes of science
3A	Children	3B	Development of children's potentials
4A	Society		

Correct Responses to Pretests (cont'd)

Objective 2:

1A	Ways scientists think and work	1B	Processes of science
2A	Subject matter	2B	Products of science
3A	Subject matter	3B	Products of science
4A	Subject matter	4B	Products of science
5A	Children	5B	Dev. of children's potentials
6A	Subject matter	6B	Products of science
7A	Subject matter	7B	Products of science
8A	Subject matter	8B	Products of science
9A	Ways scientists think and work	9B	Processes of science
10A	Children	10B	Dev. of children's potentials

Objective 3:

Preferred emphasis: (Either of the three major emphases is acceptable)

Many different responses are acceptable--depending upon which emphasis is favored and which two are tentatively rejected--however, in order for a response to be acceptable, it should be a seemingly legitimate reason.

For example, this statement is acceptable if the processes of science is the favored emphasis:

> "I believe process skills will be more useful to pupils than the products of science because the processes can be used in many situations and the products of science are soon forgotten."

This statement is not acceptable (assuming the favored emphasis is the products of science):

> "I believe the products of science are important because they were derived from an analysis of subject matter."

Correct Responses to Pretests (cont'd)

5. Differentiating Between Product- and Process-Centered Instructional Objectives

Objective 1: 1-Ps, 2-Ps, 3-Pt, 4-Ps, 5-Pt, 6-Pt, 7-Pt, 8-Pt, 9-Pt, 10-Ps, 11-Ps, 12-Pt, 13-Pt, 14-Ps, 15-Ps

6. Developing a Philosophy of Science Education

Objective 1: 1-I, 2-I, 3-E, 4-I, 5-I, 6-E, 7-I, 8-E, 9-I, 10-E

Objective 2: Students who tend to believe in the experiential viewpoint should have checked statements: 1, 2, 4, 6, 7, and 8.

Students who tend to believe in the instructional viewpoint should have checked statements: 3, 4, 9 and 10.

Objective 3: (Many different responses are acceptable)

Examples: If a student has tentatively adopted the instructional viewpoint, this statement is acceptable:

"I want to know what pupils are learning and whether they are learning."

If a student has tentatively rejected the experiential viewpoint, this statement is acceptable:

"The experiential viewpoint presupposes that children are self-motivated to learn and will seek out appropriate learning experiences. I don't believe it."

If a student has tentatively adopted the experiential viewpoint, this statement is acceptable:

"I teach kindergarten, and I know these approaches work with the children I teach."

Correct Responses to Pretests (cont'd)

If a student has tentatively *rejected* the *instructional* viewpoint, this statement is acceptable:

"There is not in existence a list of generally agreed upon products and processes of science that children *need* to know."

7. Identifying Guides to be Used in Planning, Directing, and Evaluating Instructional Activities

Objective 1: 1-B, 2-A, 3-D, 4-G, 5-F, 6-G, 7-F, 8-C, 9-G, 10-G, 11-C, 12-B, 13-E, 14-B, 15-H

Objective 2: Many different responses are possible - depending upon the manual(s) used--use instructor judgment.

8. Curricular Components of The Instructional Approaches

Objective 1: Responses do not have to be exactly as below:

1. Instructional objectives - a precise description of the science products and processes pupils are to learn or acquire which is used in planning, directing, and evaluating instructional activities.
2. Pretest or preassessment - used to determine which pupils need additional instruction, or to determine the level of student achievement prior to instruction.
3. Instruction - the activities which the learner engages in in order to master the instructional objectives.
4. Practice - opportunities for the student to engage in the behavior described in the instructional objective in order for him to develop a high proficiency in the behavior or skill.
5. Post-test or postassessment - a test or evaluation instrument used primarily to determine the effectiveness of a teacher's instructional activities.

Objective 2: 1-Instruction, 2-Objectives, 3-Post-test, 4-Objectives, 5-Pretest, 6-Instruction, 7-Instruction, 8-Objectives, 9-Pretest, 10-Practice

Correct Responses to Pretests (cont'd)

9. Developing Children's Potentials using the Experiential Approaches

Objective 1: 1-B, 2-B, 3-B, 4-B, 5-B, 6-A, 7-A, 8-A, 9-B, 10-B

Objective 2: 1-A, 2-B, 3-A, 4-A, 5-B, 6-B, 7-B, 8-B, 9-B, 10-A

10. Types of Activities

Objective 1: 1-F, 2-A, 3-C, 4-B, 5-B, 6-D, 7-F, 8-D, 9-A, 10-B

Objective 2: 1-A, 2-B, 3-B, 4-B, 5-B, 6-B, 7-A, 8-B, 9-B, 10-A

11. Developing a Proper Support System

Objectives 1 and 2: Jack Dossett -- A-True, B-True, C-True, D-True, E-True

Mabel Sundberg -- A-True, B-True, C-True, D-True, E-There is nothing in the teacher's training and experience to indicate she could effectively implement the support system -- (but she evidently can!)

Jean Strader -- A-True, B-True, C-True, D-True, E-True

12. Improved Science Programs

Objective 1: 1-B, 2-A, 3-C, 4-C, 5-B, 6-A, 7-C, 8-A, 9-B, 10-A, 11-B, 12-A, 13-B, 14-B, 15-A, 16-B, 17-B, 18-A, 19-A, 20-A, 21-C, 22-A, 23-C, 24-B, 25-A, 26-B, 27-A, 28-B, 29-C, 30-A

Correct Responses to Post-tests

1. Ends and Means and Pacing Learning Activities

Objective 1: 1-E, 2-M, 3-M, 4-M, 5-E, 6-E, 7-E, 8-M, 9-M, 10-M, 11-M, 12-M, 13-E, 14-M, 15-E

Objective 2: 1-T, 2-P, 3-P, 4-P, 5-T, 6-T, 7-T, 8-T, 9-P, 10-T

2. Alternative Approaches in Elementary Science Education

Objective 1: 1-TTTL, 2-TTPI, 3-TTTL, 4-TTTL, 5-TTPI, 6-TTPI, 7-TTPI, 8-TTTL, 9-TTTL, 10-PPPI

Objective 2: (Many different responses are acceptable - see examples on Pretest Responses)

3. Individualizing Instruction

Objective 1:

	A	B	C
1		x	x
2		x	x
3			
4			
5	x	x	x
6			x
7			
8		x	x
9			
10		x	x

4. Sources of Objectives and Emphases in Science Education

Objective 1: (The order below is not important; however, the A and B responses should correspond as below.)

1A	Subject matter	1B	Products of science
2A	Ways scientists think and work	2B	Processes of science
3A	Children	3B	Dev. of children's potentials
4A	Society		

Correct Responses to Post-tests (cont'd)

Objective 2:

1A	Ways scientists think and work	1B	Processes of science
2A	Ways scientists think and work	2B	Processes of science
3A	Subject matter	3B	Products of science
4A	Subject matter	4B	Products of science
5A	Subject matter	5B	Products of science
6A	Ways scientists think and work	6B	Processes of science
7A	Subject matter	7B	Products of science
8A	Subject matter	8B	Products of science
9A	Children	9B	Dev. of children's potentials
10A	Subject matter	10B	Products of science

Objective 3: (See comments for Objective 3 Pretest)

5. Differentiating Between Product- and Process-Centered Instructional Objectives

Objective 1: 1-Pt, 2-Pt, 3-Pt, 4-Pt, 5-Ps, 6-Ps, 7-Pt, 8-Ps, 9-Ps, 10-Pt, 11-Pt, 12-Pt, 13-Ps, 14-Ps, 15-Pt

6. Developing a Philosophy of Science Education

Objective 1: 1-I, 2-E, 3-I, 4-I, 5-E, 6-I, 7-I, 8-E, 9-E, 10-I

Objective 2: Students who tend to believe in the experiential viewpoint should have checked statements: 4, 5, 6, 9, and 10.

Students who tend to believe in the instructional viewpoint should have checked statements: 1, 2, 3, 7, and 8.

Objective 3: (Many different responses are acceptable - see examples on Pretest Responses)

7. Identifying Guides to be Used in Planning, Directing, and Evaluating Instructional Activities

Objective 1: 1-C, 2-C, 3-D, 4-E, 5-G, 6-B, 7-E, 8-F, 9-G, 10-A, 11-A, 12-G, 13-B, 14-H, 15-F

Objective 2: (Many different responses are possible - depending upon the manual(s) used.)

Correct Responses to Post-tests (cont'd)

8. Curricular Components of the Instructional Approaches

Objective 1: Responses do not have to be exactly as below:

1. Instructional objectives - a precise description of the science products and processes pupils are to learn or acquire which is used in planning, directing, and evaluating instructional activities.
2. Pretest or preassessment - used to determine which pupils need additional instruction, or to determine the level of student achievement prior to instruction.
3. Instruction - the activities which the learner engages in in order to master the instructional objectives.
4. Practice - opportunities for the student to engage in the behavior described in the instructional objective in order for him to develop a high proficiency in the behavior or skill.
5. Post-test or postassessment - a test or evaluation instrument used primarily to determine the effectiveness of a teacher's instructional activities.

Objective 2: 1-Post-test, 2-Instruction, 3-Objectives, 4-Pretest, 5-Instruction, 6-Post-test, 7-Instruction, 8-Objectives, 9-Pretest, 10-Practice

9. Developing Children's Potentials using the Experiential Approaches

Objective 1: 1-A, 2-B, 3-B, 4-A, 5-B, 6-B, 7-A, 8-B, 9-A, 10-A

Objective 2: 1-B, 2-B, 3-B, 4-A, 5-B, 6-B, 7-B, 8-A, 9-B, 10-A

10. Types of [illegible]

Objective 1: 1-B, 2-C, 3-[illegible], 4-[illegible], 5-F, 6-B, 7-D, 8-E, 9-A, 10-A

Objective 2: 1-B, 2-B, 3-A, 4-[illegible], 5-A, 6-B, 7-B, 8-A, 9-B, 10-B

Correct Responses to Post-tests (cont'd)

11. Developing a Proper Support System

Objectives 1 and 2: *Angela Hockensmith* -- A-True, B-True, C-False--She believes the products of science should be emphasized but the support system provided by her school is process centered. D-True, E-True.

Margaret Allison -- A-True, B-False--She believes in the experiential viewpoint while her materials are likely instructional in nature. C-False--She believes emphasis should be placed upon development of children's potentials, but her support system is composed largely of books which are probably product centered. D-True, E-True.

Myrtle Castleberry -- A-True, B-True, C-True, D-True, E-False--Proper implementation of the support system requires skills which permit student pacing of learning activities in an independent setting. There is nothing in the teacher's training or experience that indicates she can implement the support system effectively or use it as it is intended to be used.

12. Improved Science Programs

Objective 1: 1-A, 2-C, 3-B, 4-A, 5-B, 6-A, 7-B, 8-B, 9-C, 10-A, 11-B, 12-B, 13-B, 14-A, 15-C, 16-A, 17-C, 18-C, 19-B, 20-B, 21-B, 22-A, 23-A, 24-A, 25-A, 26-C, 27-A, 28-B, 29-C, 30-A

Pretest and Post-test Scores of Students During Tryouts of Materials

The materials were tried out under less than desirable circumstances. First, very small groups of students were available, or were enrolled in the classes in which the materials were tried out. Second, the background and experience of students in the tryout groups differed greatly.

Three groups of students were involved in the tryout of the materials. One group was composed of five graduate students enrolled in an elective two semester hour course in science education. The group included one person (M. R.) who had recently completed the bachelor's degree and was commencing her first year of teaching, two persons (S. S. and A. T.) who had two-three years experience, one person (M. T.) who had taught six years but who was not teaching while taking the course, and one person (J. T.) who had taught special education for a number of years. Nine first edition exercises were tried out with this group.

The three exercises which were not ready for tryout with the first group were later tried out in an elective three semester hour undergraduate science education class. The scores of students in this group are identified by the initials J. B., D. B., R. B., S. G., and C. K.

The third group, which tried out all twelve second edition exercises except the pretest for objective two in the exercise "Identifying Guides . . .," was composed of four students enrolled in an elective two semester hour graduate science education course. Their experience ranged from one year as a substitute teacher to twenty years experience. B. R. had substituted for one year, B. K. had taught for five years, C. R. for twelve years, and B. N. had twenty years experience.

Although there are probably a number of factors in addition to the group differences which might account for the differences between pretest and post-test scores, and between post-test scores of different groups not being what one might expect, the writer is aware of three factors which likely influenced some scores. First, students who took the pretests of the first edition materials took them immediately prior to receiving the instructional exercises. Since some exercises served as prerequisites for others, one would expect these students to score higher on some pretests than students who used the second edition materials who took all of the pretests early in the semester.

A second factor that likely influenced some scores was that, as the project progressed, the writer became more critical and less accepting of statements given in response to items which required students to express a belief or opinion. Statements accepted as "correct" on some first edition pretests and post-tests might not have been accepted on second edition tests.

Third, students who worked with the second edition materials were asked to work at a much faster pace than students who worked with the first edition materials in order for the project to be completed by the mid-semester project termination date.

It should be noted that no discussions were held, and no instruction was provided other than that contained in the instructional exercises, and that referred to in the exercise "Improved Science Programs," prior to the administration of the post-tests.

Once students had taken the post-tests, discussions were held concerning the materials and the ideas expressed therein. In instances where students had done poorly on a post-test and wanted to try to improve their score, additional instruction was provided and a second post-test was administered. This was done to enable students to increase their level of knowledge and to improve their grade in the course--not as a part of the project.

ENDS AND MEANS AND PACING LEARNING ACTIVITIES

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
M. R.	11	14	9	10
S. S.	12	13	9	8
A. T.	13	14	8	10
J. T.	14	15	9	9
M. T.	12	14	6	9
Maximum Possible	15	15	10	10

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
B. K.	14	15	7	9
B. N.	11	7	6	8
C. P.	9	14	8	10
B. R.	8	14	10	10
Maximum Possible	15	15	10	10

ALTERNATIVE APPROACHES IN ELEMENTARY SCIENCE EDUCATION

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
M. R.	37	38	4	7
S. S.	39	39	1	8
A. T.	35	39	3	7
J. T.	10	38	5	8
M. T.	37	39	4	8
Maximum Possible	40	40	8	8

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
B. K.	32	38	3	6
B. N.	33	37	2	7
C. P.	27	40	2	5
B. R.	33	37	3	7
Maximum Possible	40	40	8	8

INDIVIDUALIZING INSTRUCTION

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1 Pre-	Objective 1 Post-
M. R.	19	26
S. S.	18	26
A. T.	18	27
J. T.	19	25
M. T.	18	24
Maximum Possible	30	30

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1 Pre-	Objective 1 Post-
B. K.	18	28
B. N.	19	27
C. P.	29	29
B. R.	22	28
Maximum Possible	30	30

SOURCES OF OBJECTIVES AND EMPHASES IN SCIENCE EDUCATION

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1 Pre-	Objective 1 Post-	Objective 2 Pre-	Objective 2 Post-	Objective 3 Pre-	Objective 3 Post-
M. R.	0	7	0	8	0	6
S. S.	0	7	0	9	0	5
A. T.	0	7	0	9	0	7
J. T.	0	7	0	9	0	7
M. T.	0	7	0	7	0	7
Maximum Possible	7	7	10	10	7	7

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1 Pre-	Objective 1 Post-	Objective 2 Pre-	Objective 2 Post-	Objective 3 Pre-	Objective 3 Post-
B. K.	0	7	0	9	0	5
B. N.	0	7	0	8	0	3
C. P.	0	7	0	8	0	7
B. R.	0	7	0	9	0	7
Maximum Possible	7	7	10	10	7	7

DIFFERENTIATING BETWEEN PRODUCT- AND PROCESS-CENTERED INSTRUCTIONAL OBJECTIVES

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1	
	Pre-	Post-
M. R.	8	15
S. S.	13	12
A. T.	5	15
J. T.	11	15
M. T.	9	15
Maximum Possible	15	15

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1	
	Pre-	Post-
B. K.	10	15
B. N.	6	14
C. P.	4	12
B. R.	6	15
Maximum Possible	15	15

DEVELOPING A PHILOSOPHY OF SCIENCE EDUCATION

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1		Objective 2		Objective 3	
	Pre-	Post-	Pre-	Post-	Pre-	Post-
M. R.	6	6	0	8	0	5
S. S.	9	9	6	9	4	5
A. T.	8	9	0	9	0	6
J. T.	8	10	9	10	3	5
M. T.	6	9	5	9	0	6
Maximum Possible	10	10	10	10	6	6

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1		Objective 2		Objective 3	
	Pre-	Post-	Pre-	Post-	Pre-	Post-
B. K.	8	8	7	9	0	6
B. N.	5	9	4	10	1	5
C. P.	6	7	6	10	2	5
B. R.	9	10	4	10	2	6
Maximum Possible	10	10	10	10	6	6

IDENTIFYING GUIDES TO BE USED IN PLANNING, DIRECTING, AND EVALUATING INSTRUCTIONAL ACTIVITIES

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
M. R.	8	14	Objective 2 was not developed at this stage of the project.	
S. S.	11	14		
A. T.	0	12		
J. T.	12	14		
M. T.	5	13		
Maximum Possible	15	15		

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
B. K.	8	13	Pre-test not devel.	5
B. N.	6	11		5
C. P.	0	9		3
B. R.	6	14		5
Maximum Possible	15	15		6

CURRICULAR COMPONENTS OF THE INSTRUCTIONAL APPROACHES

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
J. B.	0	10	0	8
D. B.	0	10	6	10
R. F.	0	9	0	7
S. G.	0	9	0	8
C. K.	0	8	0	10
Maximum Possible	10	10	10	10

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
B. K.	1	10	0	9
B. N.	8	10	5	8
C. P.	0	10	0	9
B. R.	3	10	6	8
Maximum Possible	10	10	10	10

DEVELOPING CHILDREN'S POTENTIALS USING THE EXPERIENTIAL APPROACHES

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
J. B. - - - - - -	7	8	10	8
D. B. - - - - - -	10	10	8	9
F. R. - - - - - -	7	10	10	10
S. C. - - - - - -	10	8	10	7
C. K. - - - - - -	10	10	10	9
Maximum Possible-	10	10	10	10

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
B. K. - - - - - -	9	9	9	10
B. N. - - - - - -	6	10	8	10
C. P. - - - - - -	9	10	9	10
B. R. - - - - - -	9	10	10	10
Maximum Possible-	10	10	10	10

TYPES OF SCIENCE ACTIVITIES

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
J. B. - - - - - -	6	8	8	7
D. B. - - - - - -	8	8	9	8
R. B. - - - - - -	0	6	9	8
S. C. - - - - - -	1	7	2	7
C. K. - - - - - -	7	6	8	8
Maximum Possible-	10	10	10	10

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1		Objective 2	
	Pre-	Post-	Pre-	Post-
B. K. - - - - - -	5	10	7	9
B. N. - - - - - -	4	10	7	8
C. P. - - - - - -	6	8	10	8
B. R. - - - - - -	6	10	9	9
Maximum Possible-	10	10	10	10

DEVELOPING A PROPER SUPPORT SYSTEM

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1	
	Pre-	Post-
M. R.	0	12
S. S.	5	14
A. T.	5	13
J. T.	9	14
M. T.	10	12
Maximum Possible	15	15

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1	
	Pre-	Post-
B. K.	8	11
B. N.	13	13
C. P.	0	10
B. R.	13	13
Maximum Possible	15	15

IMPROVED SCIENCE PROGRAMS

Pre- and Posttest Scores of Students Using First Edition Materials

Student	Objective 1	
	Pre-	Post-
M. R.	16	25
S. S.	15	21
A. T.	10	24
J. T.	21	27
M. T.	0	23
Maximum Possible	30	30

Pre- and Posttest Scores of Students Using Second Edition Materials

Student	Objective 1	
	Pre-	Post-
B. K.	7	26
B. N.	2	28
C. P.	0	19
B. R.	20	27
Maximum Possible	30	30